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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

ORGANIZATIONAL, DS, GS,
AND DEPOT MAINTENANCE MANUAL

HEWLETT-PACKARD

ELECTRONIC VOLTMETER

MODEL 410C

This copy is a reprint which includes current pages from Change 1.

HEADQUARTERS, DEPARTMENT OF THE ARMY

AUGUST 1967

WARNING

DANGEROUS VOLTAGES

EXIST IN THIS EQUIPMENT

Be careful when working on the power supplies and their circuits, or on the 115- or 230-volt ac line connections.

DON'T TAKE CHANCES!

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TM 11-6625-1614-15

TECHNICAL MANUAL
No. 11-6625-1614-15)

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *28 August* 1967

ORGANIZATIONAL, DS, GS, AND DEPOT MAINTENANCE MANUAL

HEWLETT–PACKARD ELECTRONIC VOLTMETER MODEL 410C (NSN 6625-00-969-4105)

Section			Page
I	GENERAL INFORMATION		1-1
	1-A.1.	Scope	1-1
	1-A.2.	Index of Publications	1-1
	1-A.3.	Maintenance Forms, Records, and Reports	1-1
	1-A.4.	Reporting Errors and Recommending Improvements	1-2
	1-A.5.	Reporting Equipment Improvement Recommendations (EIR)	1-2
	1-A.6.	Administrative Storage	1-2
	1-1.	Description	1-4
	1-4.	Accessories Available	1-5
II	INSTALLATION		2-1
	2-1.	Inspection	2-1
	2-3.	Installation	2-1
	2-5.	Rack Mounting	2-1
	2-9.	Three - Conductor Power Cable	2-1
	2-12.	Primary Power Requirements	2-1
	2-14.	Repackaging for Shipment	2-2
III	OPERATION		3-1
	3-1.	Introduction	3-1
	3-3.	Adjustment of Mechanical Zero	3-1
	3-5.	Front and Rear Panel Description	3-1
	3-7.	Operating Procedures	3-1
	3-9.	DC Voltage Measurements (Figure 3-2)	3-1
	3-11.	DC Current Measurements (Figure 3-3)	3-1
	3-13.	AC Voltage Measurements (Figure 3-4)	3-1
	3-15.	Precautions When Measuring AC Voltage	3-1
	3-28.	Negative Pulses	3-4
	3-31.	Measuring Resistance (Figure 3-7)	3-4
	3-33.	Measuring DC Nano-Ampere Current (Figure 3-8)	3-4
IV	THEORY OF OPERATION		4-1
	4-1.	Overall Description	4-1
	4-4.	Circuit Description	4-1
	4-5.	Input Network	4-1
	4-16.	Modulator - Demodulator	4-1
	4-23.	The Feedback Network	4-2
	4-27.	Power Supply	4-2
V	MAINTENANCE		5-1
	5-1.	Introduction	5-1
	5-3.	Test Equipment Required	5-1
	5-5.	Performance Checks	5-1

Section		Page
5-7.	Alternate Voltage Source	5-1
5-9.	Mechanical Meter Zero	5-1
5-10.	DC Voltmeter OWration	5-1
5-13.	DC Ammeter Operation	5-2
5-16.	Ohmmeter Operation	5-4
5-17.	Amplifier Operation	5-4
5-21.	DC Amplifier Output Impedance Check	5-5
5-22.	AC Voltmeter Operation	5-5
5-26.	Adjustment and Calibration Prmedure	5-8
5-28.	Chopper Frequency Adjust	5-8
5-29.	Power Supply Adjustment	5-9
5-30.	DC Zero Adjustment and Bias	5-10
5-31.	DC Amplifier Output Adjust	5-10
5-33.	Ohms Adjust (R3)	5-11
5-34.	AC Zero Adjust	5-12
5-35.	AC Full Scale Adjust (.5 V Range)	5-12
5-36.	Troubleshooting Procedure	5-12
5-45.	Servicing Etched Circuit Boards	5-14
5-48.	Chopper, Assembly Installation	5-15

LIST OF TABLES

Number		
1-1.	Specifications	1-3
3-1.	Possible Eror When Measuring Voltage of Complex Waveforms	3-3
5-1.	Recommended Test Equipment	5-0
5-2.	DCV Accuracy Test	5-2
5-3.	DCV Input Resistance Test	5-3
5-4.	DCA Accuracy Test	5-3
5-5.	Deleted	
5-6.	AC Accuracy Test	5-6
5-7.	Power Supply Test	5-9
5-8.	AC Full Scale Adjust	5-13
5-9.	Front Panel Troubleshooting Prmedure	5-16
5-10.	Troubleshooting Prwedure	5-17

LIST OF ILLUSTRATIONS

Number		*Page*
1-1.	The hp Model 410C Electronic Voltmeter	1-0
2-1.	The Combining Case	2-0
2-2.	Steps to Place Instrument in Combining Case	2-0
2-3.	Adaptor Frame Instrument Combination	2-1
2-4.	Two Half Modules in Rack Adaptor	2-2
3-1.	Front and Rear Panel Controls	3-2
3-2.	DC Voltage Measurements	3-5
3-3.	DC Current Measurements	3-6
3-4.	AD Voltage Measurements	3-7
3-5.	Maximum AC Voltage Chart for 11036A Probe	3-8
3-6.	Graph Used in Calculation of Pulse Voltage Readings	3-9
3-7.	Resistance Measurements	3-10
3-8.	DC Nano-Ampere Current Measurements	3-11
4-1.	Block Diagram, Model 410C	4-0
4-2.	Modulator - Demodulator Mechanical Analogy	4-0
4-3.	Simplified Schematic, DC Current Measurement	4-3

Number		Page
4-4.	Simplified Schematic, DC Voltage Measurements	4-4
4-5.	Simplified Schematic, Resistance Measurement	4-5
4-6.	Simplified Schematic, AC Voltage Measurement	4-6
5-1.	Alternate Voltage Source	5-1
5-2.	DC Ammeter Operation	5-3
5-3.	High Frequency Response Test	5-5
5-4.	Low Frequency Response Test	5-6
5-5.	Troubleshooting Tree	5-14
5-6.	A4 Chopper Assembly Installation	5-15
5-6.1	Chopper Frequency Adjust Setup	5-16.1
5-7.	Power Supply Measurements	5-17
5-8.	Power Supply Schematic	5-19
5-9.	Typical Amplifier Waveforms	5-20
5-10.	Amplifier Schematic	5-21
5-11.	Model 11036A AC Probe Exploded	5-22
5-12.	Model l1036A Probe Schematic	5-22
5-13.	RANGE and FUNCTION Switching (Pictorial)	5-23
5-14.	Input RANGE and FUNCTION Switching Schematic	5-24

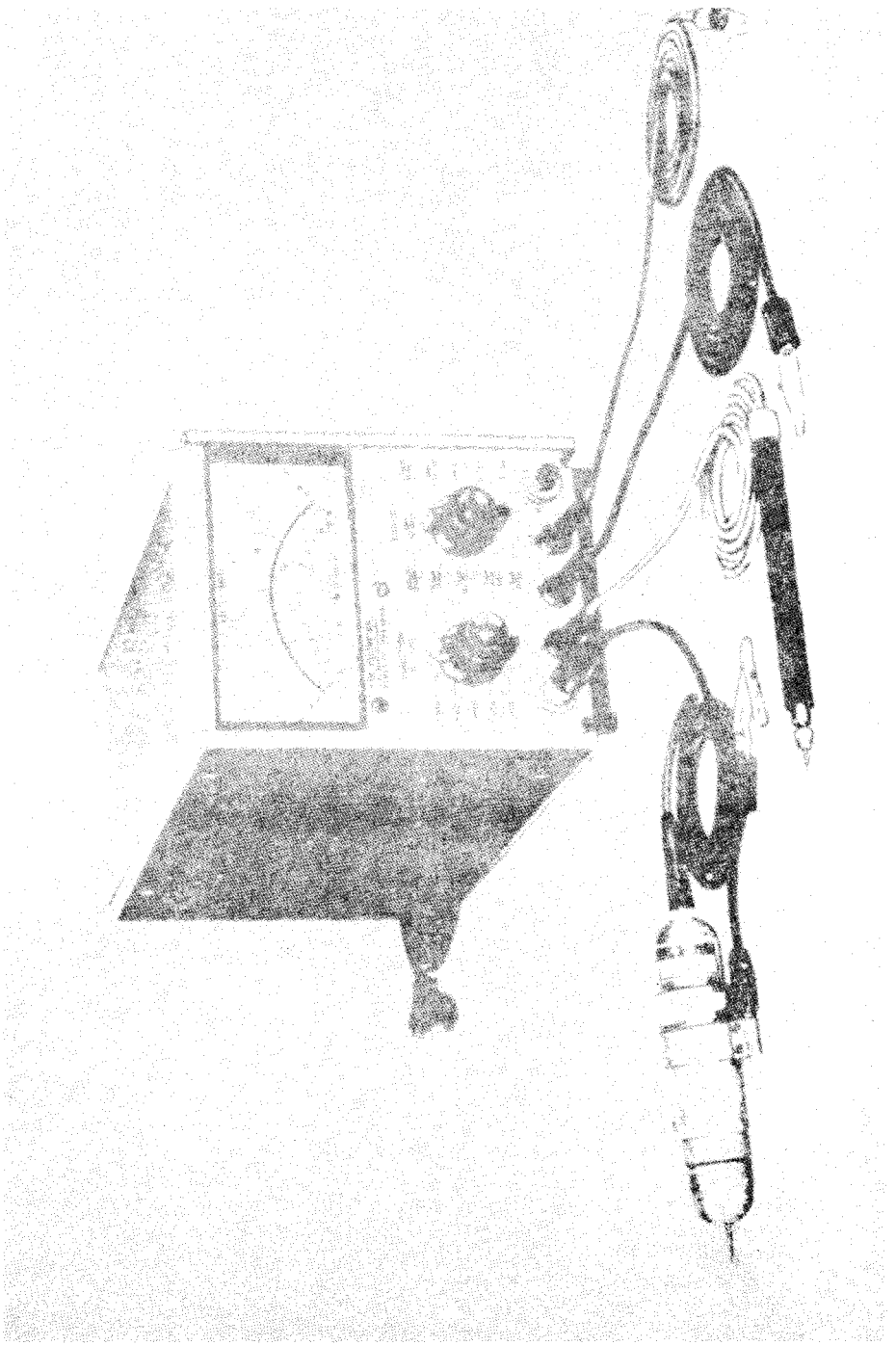


Figure 1-1. The Model 410C Electronic Voltmeter

SECTION I
GENERAL INFORMATION

1-A.1. Scope

a. This manual includes installation and operation instructions and covers operator's, organizational, direct support (DS), general support (GS), and depot maintenance. It describes Hewlett-Packard (Federal supply code 28480) Electronic Voltmeter Model 410C. This manual applies to equipments with serial numbers prefixed by 433 and serial number 532-03701 and higher. If the first three digits on your instrument are 550, refer to figure 5-10, note 14 for the change in equipments of this serial prefix.

b. A basic issue iterns list for this equipment is not included as part of this manual.

1-A.2. Index of Publications

Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

1-A.3. Maintenance Forms, Records, and Reports

a. Reports of Maintenance and Unsatisfactory Equipment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by TM 38-750, The Army Maintenance Management System.

b. Report of Item and Packaging Discrepancies. Fill out and forward SF 364 (Report of Discrepancy (ROD)) as prescribed in AR 735-1l-2/DLAR 4140. 55/NAVMATINST 4355.73/AFR 400.54/MCO 4430.3E.

c. Discrepancy in Shipment Report (DISREP) (SF361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAVSUPINST 4610.33B/AFR 75-18/MCO P4610.19C and DLAR 4500.15.

1-A.4. Reporting Errors and Recoin. mending Improvements

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), direct to Commander, US Army Communications and Electronics Materiel Readiness Command, ATTN: DRSEL-ME-MQ, Fort Monmouth, NJ 07703. A reply will be furnished to you.

1-A.5. Reporting Equipment Improve. ment Recommendations (EIR)

If your Electronic Voltmeter needs improvement, let us know. Send us and EIR. You, the user are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Tell us why a procedure is hard to perform. Put it on an SF 368 (Quality Deficiency Report). Mail it to Commander, US Army Communications and Electronics Materiel Readiness Command, ATTN: DRSEL-ME-MQ, Fort Monmouth, NJ 07703. We'll send you a reply.

1-A.6. Administrative Storage

Administrative storage of this equipment consists of covering the equipment with heavy paper taped in a way to prevent entry of dust particles. If environment is humid, use bags of dessicant inside the paper covering.

Table 1-1. Specifications

DC VOLTMETER

Voltage Range: ±15 mv to ±1500 v full scale in 15, 50, 150 sequence (11 ranges).

Accuracy: ±2% of full scale on any range.

Input Resistance: 100 megohms ±1% on 500 mv range and above. 10 megohms ±3% on 15 mv, 50 mv, and 150 mv ranges.

DC AMMETER

Current Ranges: ±1.5 μa to ±150 ma full scale in 1.5, 5, 15 sequence (11 ranges).

Accuracy: ±3% of full scale on any range.

Input Resistance: Decreasing from 9 k ohms on 1.5 μa scale to approximately 0.3 ohms on the 150 ma scale.

Special Current Ranges: ±1.5, ±5, and ±15 nanoamps full scale may be measured on the 15, 50 and 150 millivolt ranges using the Voltmeter Probe, with ±5% accuracy and 10 megohm input resistance.

OHMMETER

Resistance Range: Resistance from 10 ohms to 10 megohms center scale (7 ranges).

Accuracy: Zero to midscale: ±5% of reading or ±2% of midscale, whichever is greater.

±7% from midscale to scale value of 2
±8% from scale value of 2 to 3
±9% from scale value of 3 to 5
±10% from scale value of 5 to 10

AMPLIFIER

Voltage Gain: 100 maximum

AC Rejection: 3 db at 1/2 cps; approximately 66 db at 50 cps and higher frequencies for signals less than 1600 v peak or 30 times full scale, whichever is smaller.

Isolation: Impedance between common and chassis is >10 megohms in parallel with 0.1 μf. Common may be floated up to 400 v dc above the chassis for dc and resistance measurements.

Output: Proportional to meter indication; 1.5 v dc at full scale: maximum current, 1 ma.

Output Impedance: Less than 3 ohms at dc.

Noise: Less than 0.5% of full scale on any range (p-p).

DC Zero Drift: Less than 0.5% of full scale/year at constant temperature. Less than 0.05% of full scale/°C.

Overload Recovery: Recover from 100:1 overload in < 3 seconds.

AC VOLTMETER: (Ⓗ Model 11036A AC Probe required).

Ranges: 0.5 v full scale to 300 v in 0.5, 1.5, 5 sequence (7 ranges).

Accuracy: ±3% of full scale at 400 cps for sinusoidial voltages from 0.5 volts to 300 volts. The AC Probe responds to the positive peak-above-average value of signal applied. The instrument is calibrated in rms volts for sine-wave inputs.

Frequency Response: ±2% at 100 mc; ±10% from 20 cps to 700 mc (400 cps reference). Indications to 3000 mc.

Frequency Range: 20 cps to 700 mc.

Input Impedance: Input capacity 1.5 pf; input resistance >10 megohms at low frequencies. At high frequencies impedance drops off due to dielectric loss.

Safety: The probe body is grounded to chassis at all times for safety. All ac measurements are referenced to chassis ground.

Meter: Individually calibrated taut band meter responds to positive peak-above-average. Calibrated in rms volts for sine wave input.

GENERAL

Maximum Input: DC: 100 v on 15, 50 and 150 mv ranges: 500 v on 0.5 to 15 v ranges; 1600 v on higher ranges. AC: 100 times full scale or 450 v peak, whichever is less.

Power: 115 or 230 v ±10%. 50 to 1000 cps, 13 watts (20 watts with Ⓗ Model 11036A AC Probe).

Dimensions: 6-17/32 in. (16.5 cm) high, 5-1/8 inches (13.01 cm) wide, 11 in. (27.9 cm) deep behind panel.

Weight: Net 8 lbs (4.0 Kg); shipping approx. 14 lbs. (6.35 Kg).

Accessory Furnished: Detachable power cord. NEMA plug; Ⓗ Model 11036A AC Probe.

Option 02: Ⓗ Model 410C less AC Probe.

01556-2

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 4l0C Electronic Voltmeter can be used to measure DC voltage and DC current; AC voltage and resistance. Positive and negative DC voltages from 10 millivolts to 1500 volts and positive and negative DC currents from 1.5 microamperes to 150 milliamperes can be measured full scale. Resistance from 10 ohms to 10 megohms full scale can be measured with an accuracy of ±5% of reading at midscale; resistance from 0.2 ohms to 500 megohms can be measured with reduced accuracy. The Model 410C Electronic Voltmeter is shown in Figure 1-1; the specifications are given in Table 1-1.

1-3. With the Model 11036A detachable AC Probe, the Voltmeter can be used to measure AC voltage from 20 cps to 700 Mc. From 20 cps to 100 Mc, AC voltage from 0.5 to 300 volts can be measured; from 100 Mc to 700 Mc, refer to Figure 3-5 for maximum AC voltage that can be applied to the AC Probe. For additional information on the AC Probe, refer to Paragraph 1-8.

1-4. ACCESORIES AVAILABLE .

1-5. MODEL 11036A AC PROBE. This accessory, when used with the Model 410C, permits AC voltage measurements from 0.5 volt rms to 300 volts rms, full scale over a frequency range of 20 cps to 700 Mc. Reference calibration accuracy at 400 cps (sinusoidal) is ±3% of full scale. Frequency response is ±10% from 20 cps to 700 Mc, with indications obtainable to 3000 Mc. Frequency response at 100 Mc is within ±2%. The Model 110364 responds to the positive-peak-above-average value of the signal applied. The Model 410C is calibrated to read in RMS volts, for sine wave inputs .

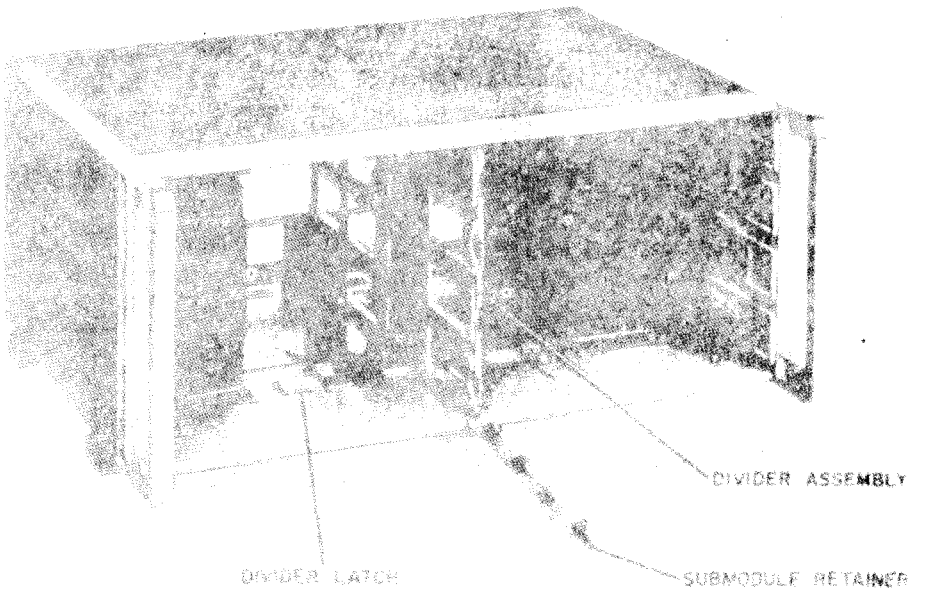


Figure 2-1. The Combining Case

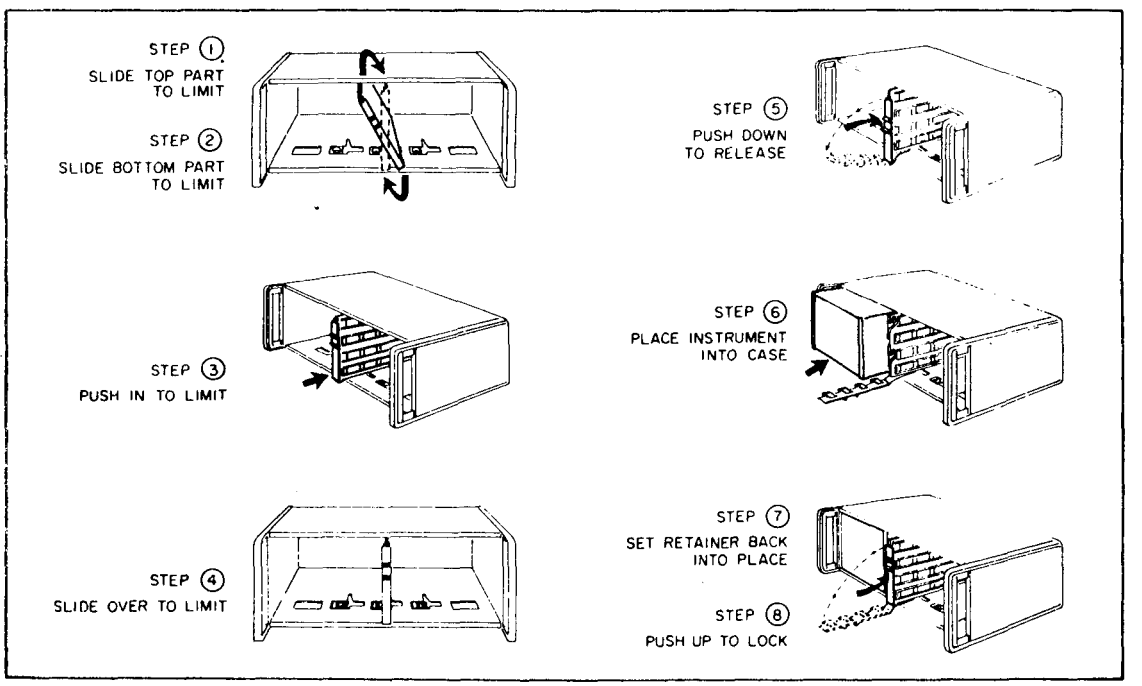


Figure 2-2. Steps to Place Instrument in Combining Case

SECTION II
INSTALLATION

2-1. INSPECTION.

2-2. 'This instrument was carefully inspected both mechanically and electrically, before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also, check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5 Performance Checks. If there is any damage or deficiency, refer to paragraph 1-A.3.

2-3. INSTALLATION.

2-4. The Model 410C is transistorized except for one vacuum tube and requires no special cooling. However, the instrument should not be operated where the ambient temperature exceeds 55° C (140° F).

2-5. RACK MOUNTING.

2-6. The Model 410C is a submodular unit designed for bench use. However, when used in combination with other submodular units, it can be bench and/or rack mounted. The Combining Cases and Adapter Frame are designed specifically for this purpose.

2-7. MODELS 1051A AND 1052A COMBINING CASES. The Combining Cases are full-module unita which accept various combinations of submodular units. Beinga full width unit, it can either be bench or rack mounted. An illustration of the Combining Case is shown in Figure 2-1. Instructions for installing the Model 410C are shown in Figure 2-2.

2-8. RACK ADAPTER FRAME (Part No. 5060-0797). The adapter frame is a rack mounting frame that accepts various combinations of submodular units. It can be rack mounted only. An illustration of the adapter frame is given in Figure 2-3. Instructions are given below.

a. Place the adapter frame on edge of bench as shown in step 1, Figure 2-4.

b. Stack the submodular units in the frame as shown instep 2, Figure 2-4. Place the spacer clamps between instruments as shown in step 3, Figure 2-4.

c. Place spacer clamps on the two end instruments (see step 4, Figure 2-4) and push the combination into the frame.

d. Insert screws on either side of frame, and tighten until submodular instruments are tight in the frame.

e. The compiete assembly is ready for rack mounting.

2-9. THREE-CONDUCTOR POWER CABLE.

2-10. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which grounds the instrument when plugged into an appropriate receptacle.

2-11. To preserve the protection feature when operating ihe instrument from a two-contact outlet, use three - prong to two - prong adapter and connect the green pigtail on the adapter to ground.

2-12. PRIMARY POWER REQUIREMENTS.

2-13. The Modei 410C can be operated from either 115 or 230 volts, 50 to 1000 cps. The instrument can be easily converted from i 15- to 230- volt operation. The LINE VOLTAGE switch, S4 a two-position slide switch located at the rear of the instrument, selects the mode of AC operation. The line voltage from which the instrument is set to operate appears on the siider of the switch. A 0.25-ampere, slo-blo fuse is used for both 115- and 230-volt operation.

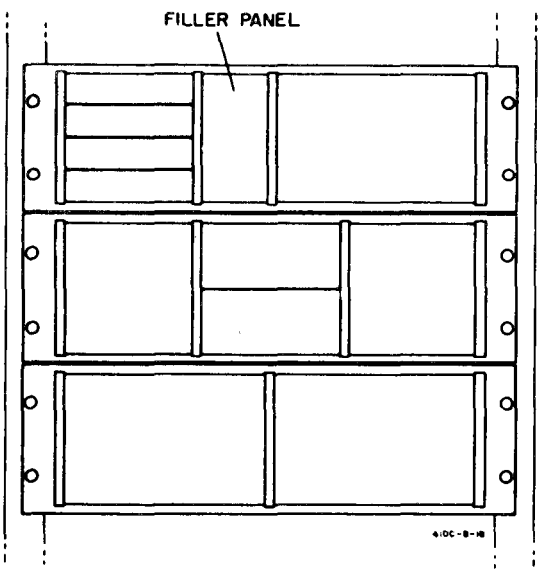


Figure 2-3. Adapter Frame Instrument Combination

CAUTION

DO NOT CHANGE THE SETTING OF THE LINE VOLTAGE SWITCH WHEN THE VOLTMETER IS OPERATING.

2-14. REPACKAGING FOR SHIPMENT.

2-15. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-16 if the original container is to be used: 2-17 if it is not.

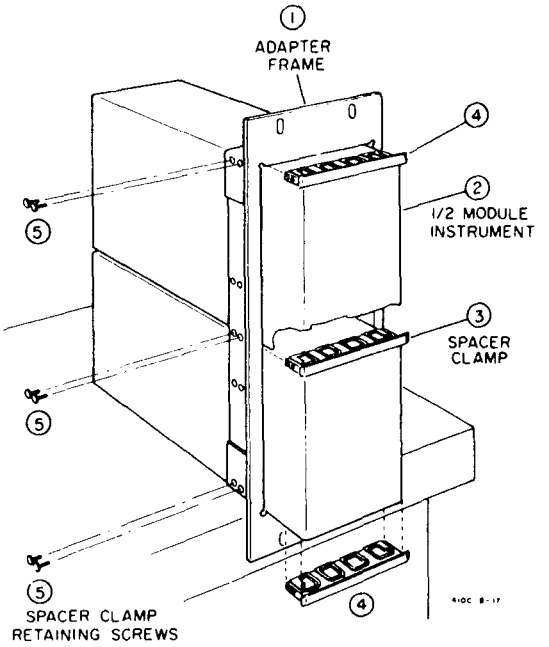


Figure 2-4. Two Half Modules in Rack Adapter

2-16. If the original container is to be used, proceed as follows:

a. Place instrument in original container if available.

b. Ensure that container is well sealed with strong tape or metal bands.

2-17. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT", "FRAGILE", etc.

SECTION III

OPERATION

3-1. INTRODUCTION.

3-2. The Model 410C is used to measure AC and DC voltage, DC current, and resistance. All measurement inputs are located on the front panel; a DC output connector is located on the rear panel. Front panel controls and indicators are color coded. DC voltage, DC current and resistance knobs and indicators are in black; AC voltage controls and indicators are in red.

3-3. ADJUSTMENT OF MECHANICAL ZERO.

3-4. The procedure for adjustment of mechanical zero is given in Section V.

3-5. FRONT AND REAR PANEL DESCRIPTION.

3-6. Figure 3-1 describes the function of all front and rear panel controls, connectors and indicators . The description of each control, connector and indicator is keyed to a drawing which accompanies the figure.

3-7. OPERATING PROCEDURES.

3-8. There are five operating procedures: DC Voltage Measurements, Figure 3-2; DC Current Measurements, Figure 3-3; AC Voltage Measurements, Figure 3-4; Resistance Measurements, Figure 3-7; and Measuring DC Current in Nano-amperes, Figure 3-8.

Note

Ageing of the neon tamps in the chopper assembly can cause a change in chopper frequency which produces a slight oscillatory movement of meter pointer. If this oscillatory movement is observed, rotate Oac Freq Adj A3R5 (see Paragraph 5-28) in the ccw direction until oscillation of pointer stops.

3-9. DC VOLTAGE MEASUREMENTS (Figure 3-2).

3-10. The Model 410C is normally floating; however a shorting bar can be connected at the DC AMPLIFIER OUTPUT connector on the rear panel. When the instrument is floating, the COM Lead should not be connected to voltages greater than 400 volts.

3-11. DC CURRENT MEASUREMENTS (Figure 3-3).

3-12. General instructions for the measurement of DC current are the same as those given for DC voltage measurements, Paragraph 3-9.

3-13. AC VOLTAGE MEASUREMENT (Figure 3-4).

CAUTION

ONE SIDE OF ALMOST ALL POWER DISTRIBUTION SYSTEMS IS GROUNDED. EXTREME CAUTION MUST BE USED IF DIRECT MEASUREMENT OF POWER LINE VOLTAGES IS ATTEMPTED. IF THE GROUND CLIP LEAD IS ACCIDENTALLY CONNECTED TO THE UNGROUNDEDSIDE OF THE LINE. SEVERE DAMAGE TO THE 410C IS POSSIBLE BECAUSE OF THE SHORT CIRCUIT CREATED. POWER LINE' VOLTAGES CAN BE SAFELY MEASURED BY USING THE PROBE TIP ONLY. CONTACTING THE GROUNDED POWER CONDUCTOR WILL GIVE A READING OF 0 VOLTS WHILE CONTACTING THE UNGROUNDED LEAD WILL GIVE FULL VOLTAGE READING.

3-14. Although the Model 410C indicates a full scale AC range of 500 volts, the optional Model 11036A AC Probe should not be connected to AC voltages in excess of 300 volts RMS. AC voltage referenced to a DC voltage may be measured, but the AC Probe clip (alligator type) must be connected to the ground (⏚) of the circuit under test.

CAUTION

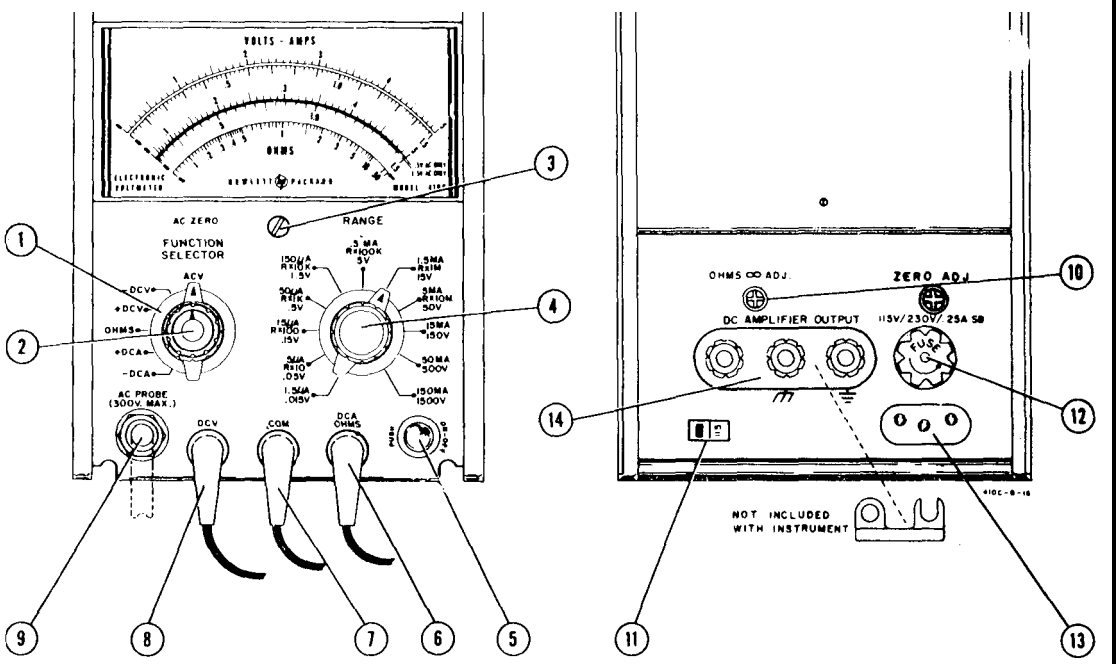
WHEN MEASURING AC REFERENCED TO DC, THE PEAK AC VOLTAGE PLUS DC VOLTAGE CONNECTED TO TRE PROBE MUST NOT EXCEED 420 VOLTS.

3-15. PRECAUTION WHEN MEASURING AC VOLTAGE.

3-16. Special considerations must be kept in mind when making AC voltage measurements. These considerations are discussed in the following paragraphs.

3-17. GENERAL CONSIDERATION OF **COMPLEX WAVEFORMS.** Waveforms containing appreciable harmonics or spurious voltages will introduce error in the meter indication since the meter has been calibrated to read RMS values of true sine waves while the Model 11036A Probe is a peak-above-average responding device.. The magnitude of error that may be expected when harmonics are present on the measured waveform is indicated in Table 3-1.

3-18. VOLTAGE MEASUREMENTS AT FREQUENCIES BELOW 50 CYCLES/SECOND. Voltage measurements at frequencies as low as 10 cycles per



1. FUNCTION SELECTOR: This control is used for selecting type of measurement to be made. They are: ±DC Voltage, ±DC Current, AC Voltage, and resistance measurements.
2. AC ZERO: This control provides adjustment for zero-setting the meter before making AC voltage measurements.
3. MECHANICAL ZERO ADJUST: This adjustment mechanically zero-sets the meter prior to turning on Voltmeter.
4. RANGE: This control selects the full scale meter range.
5. AC POWER SWITCH: This push button - lamp combination, when depressed, turns the instrument power on or off. The push button glows when the Voltmeter power is on,
6. DCA-OHMS: This lead is used in conjunction with the COM Lead to measure DC current or ohms. The FUNCTION SELECTOR determines which measurement is made.
7. COM: This lead is used with the input leads for DC voltage current, AC voltage, and resistance measurements. The COM Lead is normally floating; however, a shorting bar can be connected from the floating ground terminal to the chassis ground terminal on the DC AMPLIFIER OUTPUT connector. If a shorting bar is not used, the COM Lead is floating except when the FUNCTION SELECTOR is set to ACV.
8. DCV: This lead is used in conjunction with the COM Lead to measure ±DC voltage.
9. AC PROBE (300V MAX): Receptacle for telephone-type plug of Model 11036A AC Probe. With probe connected the Voltmeter may be used to make AC voltage measurements.
10. ∞ ADJUST: This control is used to set meter pointer to ∞ before resistance measurements are made. Only periodic adjustment of this screwdriver adjustment is necessary.
11. LINE VOLTAGE: This two-position slide switch sets the instrument to accept either 115 or 230 volt AC primary power.
12. FUSEHOLDER: The fuseholder contains a 0. 25 ampere slow-blow fuse for both 115 vac and 230 vac modes of operation.
13. AC POW ERCONNECTOR: Accepts power cable supplied with the instrument.
14. DC AMPLIFIER OUTPUT: Provides DC voltage output proportional to meter indication for driving external recorder. 1.5 volts DC output for full scale meter deflection.

Figure 3-1. Front and Rear Panel Controls

second maY be made without loss of accuracy by removing the. plastic nose on the Model 11036A and using in its place a 0.25 microfarad blocking capacitor in series with the exposed contact of the probe.

CAUTION

THE GRAY INSULATING MATERIAL AROUND THE AC PROBE IS POLYSTYRENE, A LOW-MELTING POINT MATERIAL. IT IS NOT POSSIBLE TO SOLDER TO THE CONTACT WHICH IS EXPOSED WITH THE PROBE NOSE IS REMOVED WITHOUT DESTROYING THE POLYSTYRENE.

Table 3-1. Possible Error When Measuring Voltage of Complex Waveforms

% Harmonic	True RMS Value	Voltmeter Indication
o	100	100
10% 2nd	100.5	90 to 110
20% 2nd	102	80 to 120
50% 2nd	112	75 to 150
10% 3rd	100.5	90 to 110
20% 3rd	102	87 to 120
50% 3rd	112	106 to 150

3-19. VOLTAGE MEASUREMENT AT HIGH FREQUENCIES. At frequencies above 100 megacycles the distance between the point of voltage measurement and anode of the probe diode must be made as short as possible. If feasible, substitute a small disc type capacitor of approximately 50 picofarsds for the removable tip on the probe. Solder one terminal of the button capacitor to the measurement point in the circuit and not to the probe contact. The probe contact (with tip removed) can then contact the other terminal of the capacitor for the measurement.

3-20. At frequencies above 100 megacycles considerable voltage may be built up across ground leads and along various part of a grounding piane. Consequently, to avoid erroneous readings when measuring medium and high frequency circuits, use the ground clip lead on the shell of the probe to connect the circuit ground. In some cases at the higher frequencies it maybe necessary to shorten the grounding lead on the probe.

3-21. For all measurements at higher frequencies, hold the molded nose of the probe as far from the external ground piane or from object at ground potential as can conveniently be done. Under typical conditions, this practice will keep the input capacitance several tenths of a picofarad lower than otherwise.

3-22. For measurements above approximately 250 megacycles it is almost mandatory that measurements be made on voltages which are confined to coaxial transmission iine circuits. For applications of this type, the Model 11036A Probe is particularly suitable because the physical configuration of the diode and probe is that of a concentric line, and with a few precautions it can be connected to typical coaxial transmission line circuits with little difficulty.

3-23. To connect the probe into an existing coaxial transmission line, cut the line away so the center conductor of the line is exposed through a hole large enough to clear the body of the probe. The nose of the probe should be removed for this type of measurement. Connect one terminal of a button-type capacitor of approximately 50 picofarads to the center conductor of the coaxial line so that the other terminal of the oapacitor will contact the anode connection of the probe. A close-fitting metal shield or bushing should be arranged to ground the outer cylinder of the probe to the outer conductor of the transmission line. This type of connection is likely to cause some increase in the standing wave ratio of the line at higher frequencies. The Model 11042A Probe T Connector is designed to do this job with SWR or less than 1.1 at 500 Mc (see Paragraph 1-11).

3-24. EFFECT OF PARASITIC ON VOLTAGE READINGS . At frequencies above 500 megacycles, leads or portions of circuits often resonate at frequencies two, three, or four times the fundamental Of the voltage being measured. These harmonics may cause serious errors in the meter reading. Owning to the resonant rise in the probe circuit at frequencies above 1000 megacycles, the meter may be more sensitive to the harmonics than to the fundamental. To make dependable measurements at these frequencies, the circuits being measured must be free of ail parasitics.

3-25. EFFECT OF DC PRESENT WITH AC SIGNAL. When measuring an AC signal at a point where there is a high DC potential, such as at the plate of a vacuum tube, the high DC potential may cause small leakage current through the blocking capacitor in the tip of the Model 11036A AC Probe. When the AC signal under measurement is small, the error introduced into the reading can bes significant. To avoid leakage, an additional capacitor with a dielectric such as mylar or polystyrene which has high resistance to leakage is required. (Use 5 picofarads or higher, and insert the capacitor between the point of measurement and the probe tip.)

3-26. PULSE MEASUREMENTS

3-27. POSITIVE PULSES. The Model 11036A AC Probe is peak-above-average responding and clamps the positive peak value of the applied voltage. This permits the probe to be used to measure the positive-voltage amplitude of a pulse, provided the reading obtained is multiplied by a factor determined from the following expression:

$$1.4\left(1 + \frac{t_1}{t_2} + \frac{K}{PRF}\right)$$

t_1 is the duration of the positive portion of the voltage in microseconds.

t_2 is the duration of the negative portion of the voltage in microseconds.

K is a factor determined from the expression R_o/t_1 and the graph shown as Figure 3-6, where R_o is the source impedance of the pulse generator in kilohms, and t_i is the duration of the positive portion of the pulse in microseconds.

PRF is the pulse repetition frequency in pulses per second (pps).

Suppose, for example:

t_1 = 10 microseconds

t_2 = 990 microseconds

K = 0.55

PRF = 1000 pps

To find K, assuming = 2 kilohms and t_1=10microseconds: $R_o/t_1 = 2/10° = 0.2$. Location 0.2 on the X axis of the graph shown as Figure 3-6, and reading K where X and Y axes intersect the unmarked curve. If the ratio of R_o/t_1 were greater than 1, multiply the X and Y axes by 10, and use the curve marked "R_o/t_1 and K each X10".

Solving the expression for the multiplying factor,

$$1.4 \quad 1 + \left(\frac{10}{990} + \frac{0.55}{1000}\right) =$$

$$1.4 \ (1 + 0.01 + 0.00055) =$$

$$1.4 \ (1.01055) =$$

$$1.41477$$

3-28. NEGATIVE PULSES.

3-29. In the case of a 10 microsecond negative pulse (t_2) and a pulse repetition frequency (PRF) of 1000 pps, t_1 would be 990 microseconds. Thus T_o/t_1 would be approximately 0, and from the graph it is seen that K is approximately 0. The expression would then reduce to

$$1.4 \ \left(1 + \frac{990}{10}\right)$$

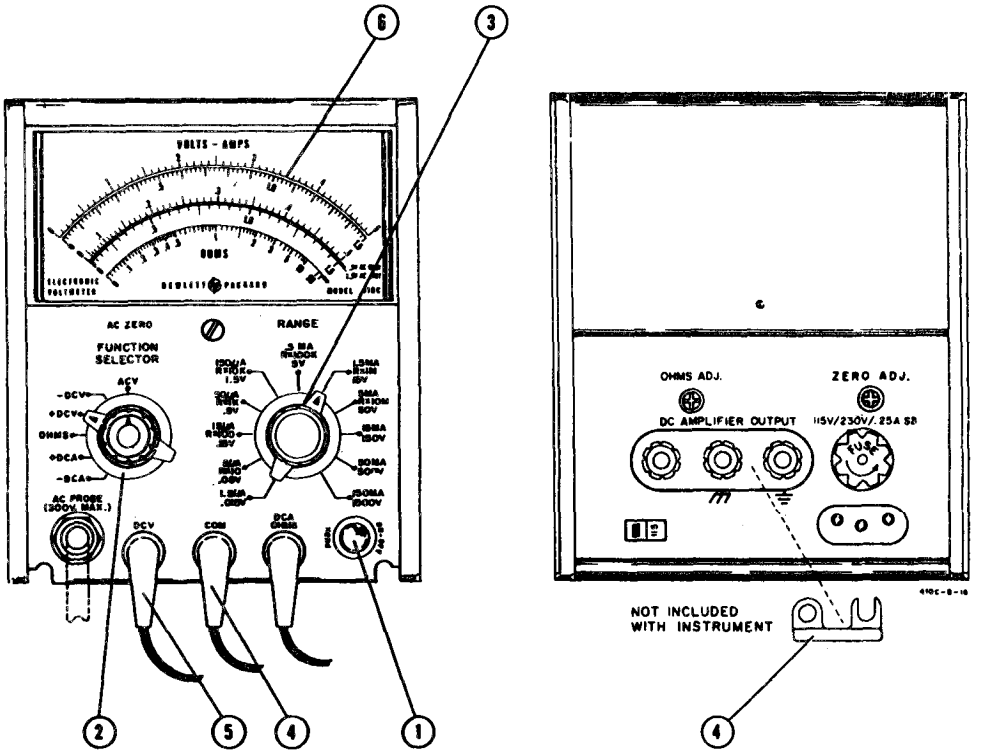
3-30. It can be seen that in the case of negative pulses of short duration much smaller readings will be obtained for an equivalent positive pulse. As a result, large multiplying factors must be used and unless the pulse voltage is large, these measurements may be impractical.

3-31. MEASURING RESISTANCE (Figure 3-7).

3-32. Before making resistance measurements, power must be removed f rom the circuit to be tested. Also, make sure capacitors are discharged to eliminate any residual voltage.

3-33. MEASURING DC NANO-AMPERE CURRENT (Figure 3-8).

3-34. The Model 410C can be used to measure nano-ampere leakage current in transistors and diodes. The three most sensitive DC voltage measurement ranges are used to measure DC nano-ampere currents.



1. Depress the AC power switch (neon - switch combination).
2. Set FUNCTION SELECTOR to polarity desired (+DCV or -DCV).
3. Set RANGE to desired voltage position.
4. Connect COM Lead to the ground of circuit under test. Do not connect common lead to voltages greater than 400 volt when making off-cabinet-ground connections.

WARNING

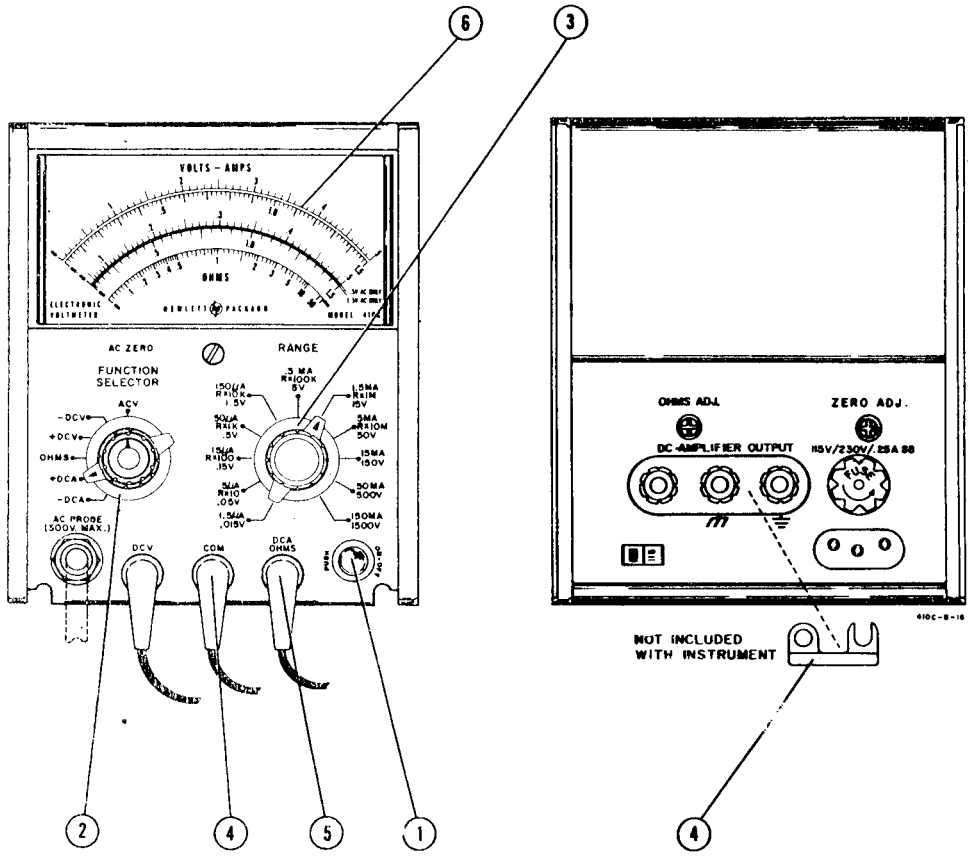
WHEN MEASURING POTENTIALS REFERENCED TO VALUES OFF GROUND, REMOVE SHORTING STRAP FROM DC AMPLIFIER OUTPUT CONNECTOR ON REAR PANEL. IF THE SHORTING STRAP IS NOT REMOVED, THE INSTRUMENT CABINET IS TIED TO THE COMMON LEAD. NORMALLY, FOR SAFETY, THE CABINET IS ALSO TIED TO EARTH GROUND THROUGH THE THIRD WIRE TO THE THREE-PRONG CONNECTOR. IF THIS THIRD WIRE CONNECTION WERE REMOVED (BY USING AN ADAPTING PLUG) THE CABINET WILL ASSUME AN ELEVATED POTENTIAL.

5. Touch DCV probe to test point.
6. Read voltage on the VOLTS-AMPS scale.

Note

Ageing of the neon lamps in the chopper assembly can cause a change in chopper frequency which produces a low amplitude oscillatory movement of the meter pointer. If the meter pointer oscillates, rotate A3R5 ccw until oscillation stops.

Figure 3-2. DC Voltage Measurements



1. Depress the AC power switch (neon-switch combination).

2. Set FUNCTION SELECTOR to the polarity desired (+DCA or -DCA).

3. Set range to desired current position.

4. Connect COM Lead to the ground of circuit under test. Do not connect common lead to voltages greater than 400 volts, when making off-cabinet ground connections.

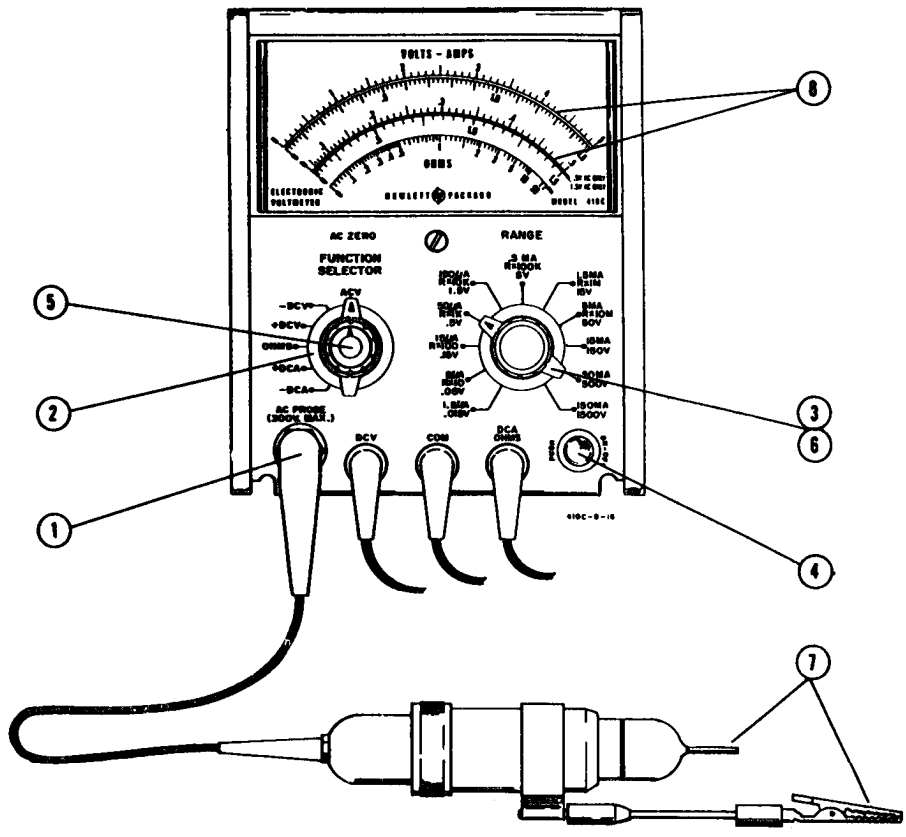
WARNING

IF THE SHORTING STRAP IS NOT REMOVED, THE INSTRUMENT CABINET IS TIED TO THE COMMON LEAD. NORMALLY FOR SAFETY, THE CABINET IS ALSO TIED TO EARTH GROUND THROUGH THE THIRD WIRE TO THE THREE-PRONG CONNECTOR. IF THIS THIRD WIRE CONNECTION WERE REMOVED (USING A TWO PRONG-TO-THREE PRONG ADAPTER), THE CABINET WILL BE AT AN ELEVATED POTENTIAL.

5. Connect the DCA ohms probe to the circuit to be tested.

6. Read the current on the VOLTS-AMPS scale.

Figure 3-3. DC Current Measurements



CAUTION

CONNECT AC PROBE CLIP TO EARTH GROUND ONLY.

1. Connect the Model 11036A AC Probe to the Model 410C at the AC PROBE receptacle.
2. Set FUNCTION SELECTOR to ACV. NOTE: COM and chassis are internally connected when the FUNCTION SELECTOR is set to ACV.
3. Set RANGE to . 5V.
4. Depress the AC power button (neon-switch combination) and allow 5 minute warmup.
5. Adjust AC ZERO for a zero indication on the meter.
6. Set RANGE to the desired voltage range.
7. Connect AC Probe clip (alligator) to ground of circuit to be tested, and touch probe tip to test point. At lower frequencies COM Lead can be substituted for the AC probe clip.

CAUTION

BEFORE MEASURING VOLTAGES AT FREQUENCIES ABOVE 100 MC, REFER TO FIGURE 3-5, TO DETERMINE THE MAXIMUM AMOUNT OF VOLTAGE THAT CAN BE APPLIED AT THAT FREQUENCY.

8. Read AC voltage on the VOLTS - AMPS scale. NOTE: When RANGE is on the . 5V and 1. 5V positions, use red meter scale.

Figure 3-4. AC Voltage Measurements

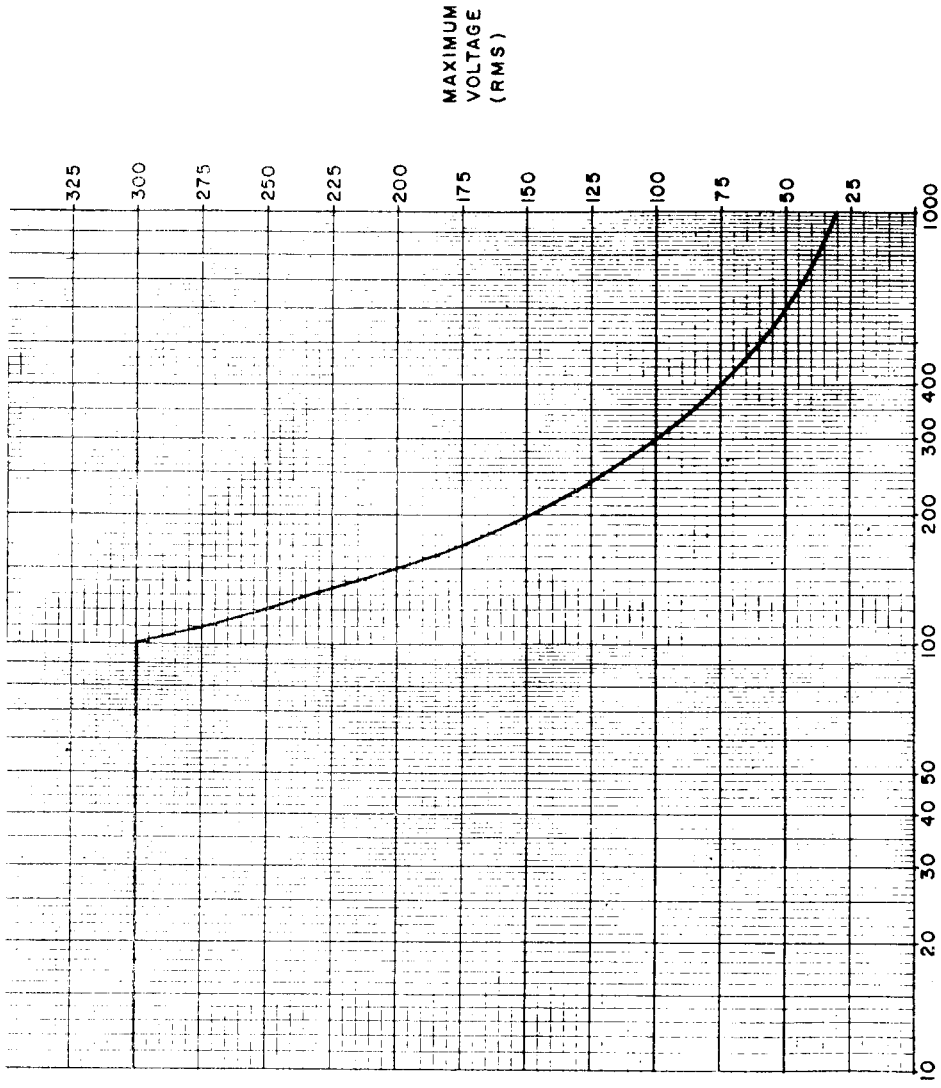


Figure 3-5. Maximum AC Voltage Chart for 11036A AC Probe

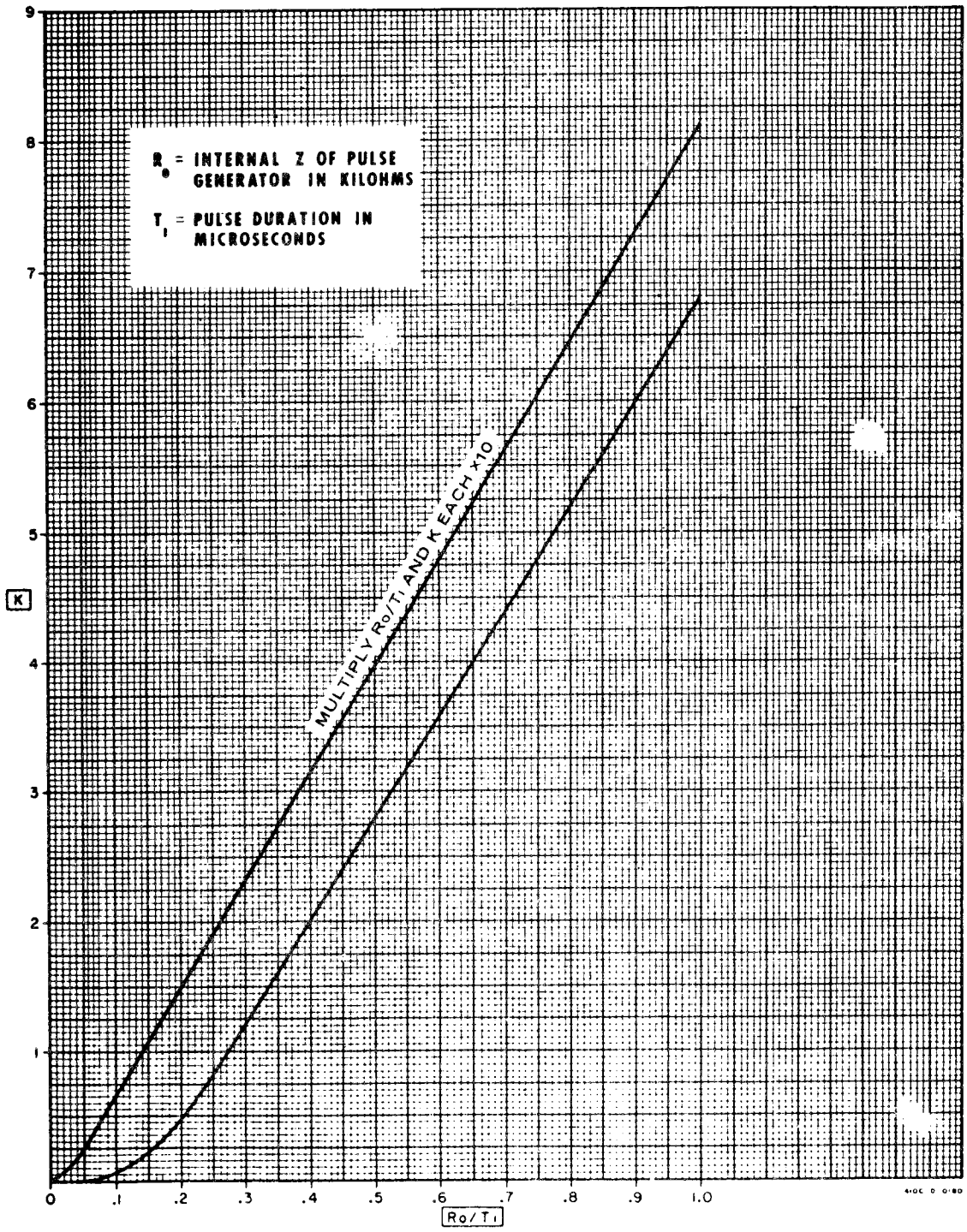
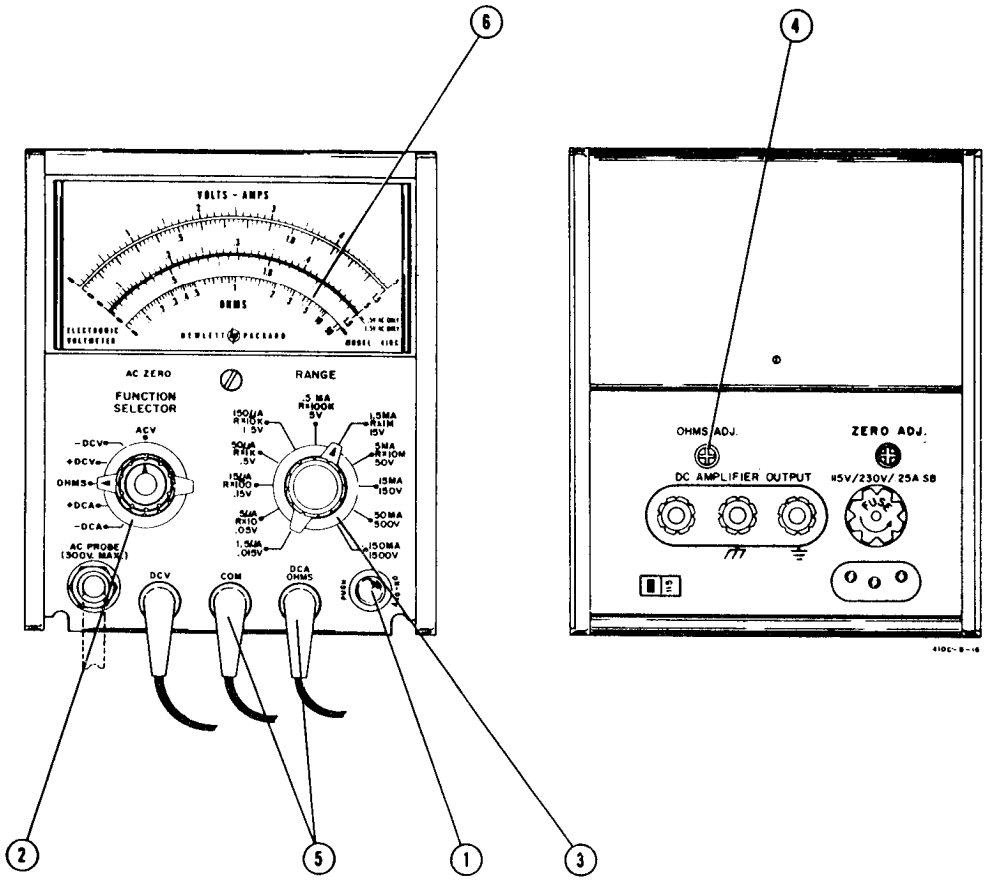


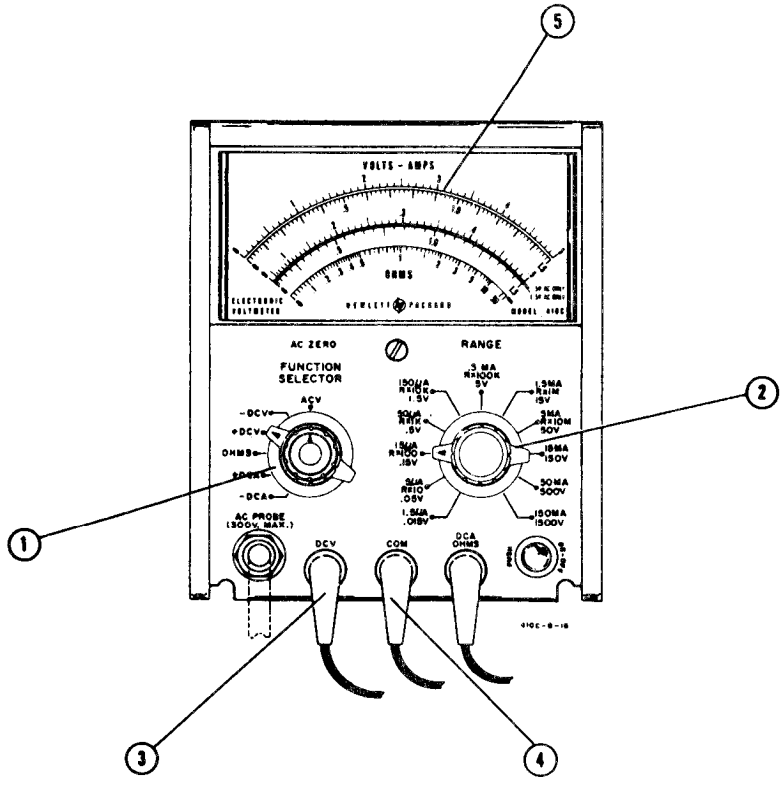
Figure 3-6. Graph Used in Calculation of Pulse Voltage Readings



Before making resistance measurements, remove power from circuit to be tested. Be sure to discharge capacitors to eliminate any residual voltage.

1. Depress AC power switch (neon-switch combination).
2. Set the FUNCTION SELECTOR to OHMS.
3. Set RANGE to desired position.
4. Adjust OHMS ∞ ADJ. control on rear panel to obtain an ∞ reading on the meter if necessary.
5. Connect COM and DCA OHMS leads across circuit to component to be tested.
6. Resistance is determined by multiplying the reading on the OHMS scale by the RANGE factor. EXAMPLE: If reading is 1.5 and factor is 10K, then resistance equals 15K ohms.

Figure 3-7. Resistance Measurements



1. **Set the FUNCTION SELECTOR to +DCV or -DCV (depending on direction of current flow).**
2. **Set RANGE to desired range (. 015V, . 05V, or . 15V range).**

Note

0.015V range = 1. 5 nano-amperes range
0. 05V range = 5. 0 nano-amperes range
0. 15V range = 15 nano-amperes range

3. Connect the DCV lead to the circuit under test.
4. Connect the COM lead to the circuit under test.
5. Read nano-amperes from the meter on the VOLTS-AMPS scale (top two on meter) which corresponds to the range selected.

Figure 3-8. DC Nano-Amoere Current Measurements

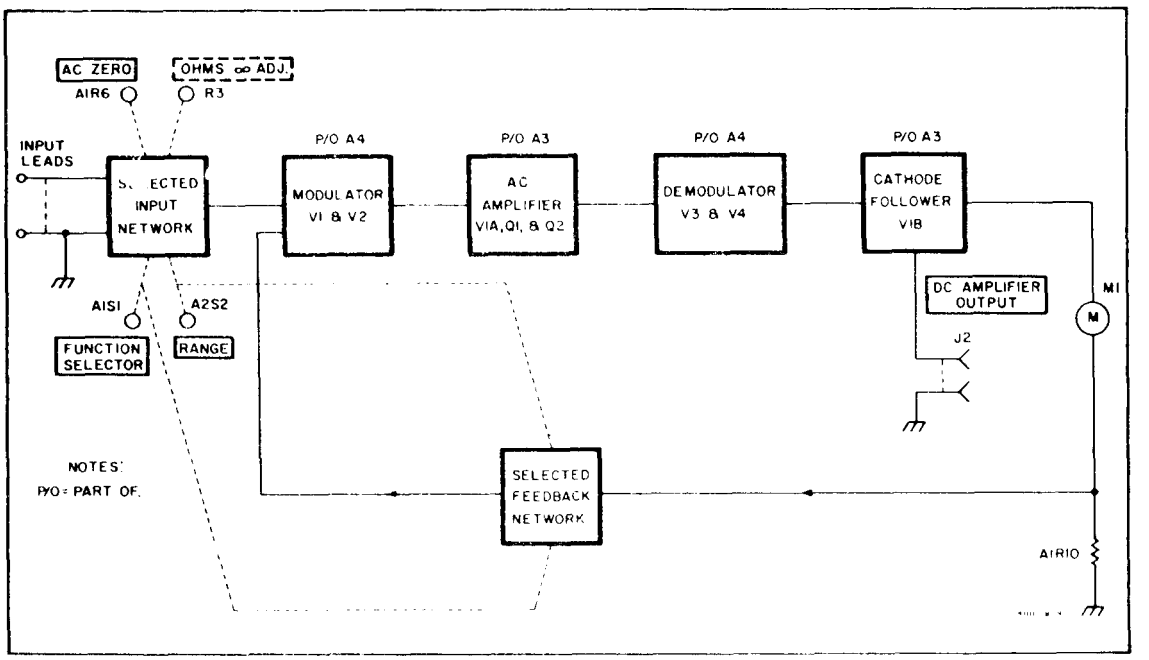


Figure 4-1. Block Diagram, Model 410C

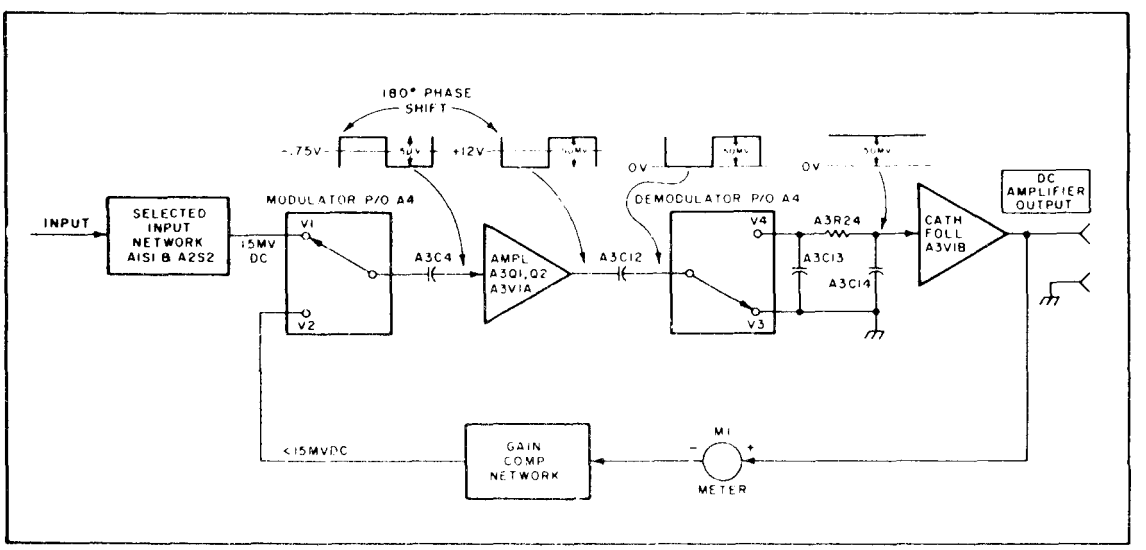


Figure 4-2. Modulator-Demodulator Mechanical Analogy

SECTION IV
THEORY OF OPERATION

4-1. OVERALL DESCRIPTION.

4-2. The Model 410C includes an input network, a modulator - amplifier- demodulator, and a meter circuit. A block diagram of the Model 410C is shown in Figure 4-1.

4-3. Signals to be measured are applied through the appropriate input lead to the input network. AC voltages are detected in the AC probe, and therefore all signals to the input network are DC. The input network attenuates the DC signal to a level determined by RANGE and FUNCTION SELECTOR settings. The attenuated DC voltage is applied to the modulator which converts the DC to AC for amplification. The amplified AC signal is converted back to DC voltage inthe demodulator and coupled to cathode follower VIB. The cathode follower output to the DC AMPLIFIER OUTPUT connector and meter circuit is a DC voltage proportional to the amplitude of the signal applied to the input. A portion of the voltage to the meter circuit is returned to the modulator as feedback. When the feedback voltage and attenuated DC voltage are nearly equal, the meter stabilizes.

4-4. CIRCUIT DESCRIPTION.

4-5. INPUT NETWORK.

4-6. The input network includes a precision voltage divider, which by means of the FUNCTION SELECTOR and RANGE switches, providesa maximum of 15 millivolts at the modulator input regardless of the range set and signal applied. The ± DCA, ±DCV, OHMS, and ACV modes of operation are discussed below.

4-7. DC CURRENT MEASUREMENTS: Refer to Figure 4-3, throughout this explanation. The purpose of the input network is to provide proper attenuation of currents applied. Currents from 1.5 µa to 150 ma full scale are applied with input impedance decreasing from 9K ohms on the 1.5 µa range to approximately 0.3 ohms on the 150 ma range.

4-6. Tbe change in input impedance is varied by using DC current shunts in conjunction with RANGE switch A2S2. The DC voltage developed across these shunt resistors, when applied through the modulator-amplifier-demodulator network to the meter, provide a deflection on the meter proportional to the DC current being measured.

4-9. DC VOLTAGE MEASUREMENTS. Refer to Figure 4-4 throughout this explanation. The purpose of the input network is to accurately attenuate the input signal to a maximum of 15 millivolts at the modulator input. The network presents an input impedance of 10 megohms on the three most sensitive ranges and 100 megohms on all other ranges.

4-10. The resistor R1 (located in the DCV probe) in conjunction with resistors A2R10 through A2R26, provides the 10 megohm input impedance required for the three most sensitive DCV ranges. Resistors A2R4 and A3R30 are shunted out of the circuit by the RANGE switch on the three most sensitive DCV ranges.

4-11. When using the eight less sensitive ranges, A2R4 and A3R30 are placed in series with Rl and A2R10 through A2R26 to present more than 100 megohm impedance to the input.

4-12. A3R30 is used to calibrate full scale on the 1500 volt range. (See Paragraph 5-35.)

4-13. RESISTANCE MEASUREMENTS. The purpose of the input network shown in Figure 4-5 is to place approximately 0. 6 volt DC source in series with a known (reference) resistance. The resistance to be measured is ptaced in parallel with the known resistance, which changes the voltage proportionally. The maximum changes in voltage applied to the modulator is 15 mv because of attenuation provided by A2R4, A3R30, and A1R2.

4-14. A DC current of approximately 60 ma is supplied at the junction of A2R22 and A2R23 through A7R10, R2, A2R2 and A2R1 to the input network. The OHMS ∞ ADJ., R3, sets the meter for full scale (∞). Resistor A2R1 is shorted out in the XIM position of the RANGE switch; resistors A2R1 and A2R2 are shorted out in the X10M range. The resistors A2R2 and/or A2R1 are electrically removed from the circuit to increase the voltage at the junction of A2R22 and A2R23. This is done to compensate for tbe loading of the attenuator (A2R4, A3R30, and A1R2) on these ranges.

4-15. AC VOLTAGE MEASUREMENTS. Refer to Figure 4-6 throughout this explanation. Voltage at the AC probe is converted to DC and applied to the input network. The input signal is attenuated to produce a maximum of about 15 millivolts at the modulator input . AC zero adjustment of meter pointer is made with the AC ‘ZERO control.

4-16. MODULATOR-DEMODULATOR.

4-17. Refer to the Amplifier Schematic, Figure 5-10 , and to the Mechanical Analogy Schematic, Figure 4-2 throughout this explanation.

4-18. The input network applies approximately 15 millivolts DC, for full scale meter deflection (positive or negative, depending on the polarity of the

voltage or current being measured) to the neon-photoconductor chopper. Also applied to the opposite side of the chopper is the amplifier feedback voltage, which is of the same polarity and approximately 5 microvolts lower in amplitude than the input voltage. The modulator-chopper consists of two photoconductors, A4V1 and A4V2, which are alternately illuminated by two neon lamps, A4DS1 and A4DS2, respectively. The neon lamps are part of a relaxation oscillator, whose frequency is controlled by A3R5. The oscillator frequency is nominally set to 100 cps for operation from 60 cps power line, or to 85 cps for 50 cps line. This frequency is selected so that it is not harmonically related to the power line frequency, precluding possible beat indications on the meter.

4-19. As the photoconductors are alternately illuminated by the neona, their respective resistances are low (conductive) when illuminated and high (non-conductive) when darkened. Therefore the input voltage and feedback voltage are alternately applied to the input amplifier. The amplitude of the resultant signal to the amplifier is the voltage difference between the input and feedback voltages.

4-20. The chopped DC signal is amplified by a three stage RC amplifier, consisting of A3V1A, A3Q1 and A3Q2. The amplified signal to the input of the demodulator-chopper is 180° out of phase with the output of the modulator-chopper.

4-21. The demodulator - chopper consists of two photoconductors, A4V3 and A4V4, which are alternately illuminated by neon tamps A4DS1 and A4DS2, respectively. Approximately 150 millivolts square-wave is applied to the demodulator from the amplifier. Since the same neon lamps illuminate both the modulator and demodulator photoconductors, operation of the two chopper is synchronous. Therefore, when A4V1 is sampling the input voltage, A4V3 is clamping the amplified and inverted difference voltage to ground. Alternately, when A4V2 is sampling the feedback voltage, A4V4 is charging capacitors A3C13 and A3C14 to the peak value of the square-wave. These capacitors maintain this charge so long as the input voltage remains constant by virtue of having no discharge path and because they are being repetitively recharged by the demodulator.

4-22. Therefore, a DC potential, proportional to the difference between the input and feedback voltages, is applied to the grid of the cathode follower and subsequently to meter circuit and DC AMPLIFIER OUTPUT connector. A portion of the meter circuit voltage is fed back to the modulator. The meter stabilizes when the feedback voltage and input voltages are nearly equal.

4-23. THE FEEDBACK NETWORK.

4-24. The feedback network drives the meter and determines the DC gain of the amplifier. The feedback is varied depending on the position of the FUNCTION and RANGE selectors. The different feedback configurations are discussed below.

4-25. FEEDBACK NETWORK FOR ±DCA. OHMS, AND ±DCV. Figures 4-3, 4-4 and 4-5 show the feedback configuration for ail positions of the FUNCTION SELECTOR except ACV. The meter is electrically inverted for ±DCV and ±DCA modes of operation. The DC OUTPUT ADJ., A6R20 sets the output voltage. The DC pot, A6R18 determines the amount of feedback to the modulator. The resistor A2R30 is in the circuit in the ± .015 DCV and ±1.5 µa modes of operation, to decrease feedback and thus increase amplifier gain to compensate for the decrease in input signal to the modulator on these ranges.

4-26. FEEDBACK CIRCUIT FORAC VOLTAGE MEASUREMENTS: Figure 4-6 shows the feedback configuration for the ACV position of the FUNCTION SELECTOR switch, A2S2. The resistors that are placed in the circuit by the RANGE switch program the amplifier gain to compensate for the non-linear response of the AC probe. A6R16 and A6CR1 compensate the non-linear response of the AC probe to the linear calibration of the upper meter scale on the 5 volt range.

4-27. POWER SUPPLY.

4-28. PRIMARY POWER. Either 115 or 230 volt ac power is connected through fuse R1 (0.25 amp slo-blo) and switch S3 to the primary of power transformer T1. Switch S4 connects T1 primaries in parallel for l15 volt operation of in series for 230 voit operation.

4-29. UNREGULATED AND ZENER REGULATED POWER SUPPLY. Full wave rectifier CR1 and CR2 produces unregulated +270 volts, which is used to drive the photochopper neons. Unregulated +175 volts and +140 volts are tapped off and are used to provide B+ to the plates of A4V1B and A4V1A, respectively. Zener regulators A7CR6 and CR7 provide regulated +38 volts and -9 volts to bias A3Ql and A3Q2. Filtering of the outputs is provided by the RC network consisting of A7R1 through A7R3 and C5A through C5D.

4-30. SERIES REGULATED POWER SUPPLY. The output of the full wave rectifier CR3 and CR4 is regulatedbytransistor Ql, which is connected in series with the output. Zener diode A7CR8 provides reference voltage to the base of Q1. Regulated +6 volts is supplied to the filaments of A3VlA/B and the AC Probe diode A6V1. +0.6 volts is provided through A7R10 to R3, the OHMS∞ ADJ, control. Filtering of the outputs is provided by C6A and C6B.

4-31. STANDBY FILAMENT SUPPLY. The filament tap (Tl, Pins 1 and 2) provides 6.0 volts actothe filament of the AC probe diode, A8V1, so that the filament remains warm when the Modei 410C is being used in modes of operation other than ACV. When FUNCTION selector A1S1 is switched to ACV, 6.0 volts AC is removed from the filament and 6 volts DC is applied. Therefore, the ACV mode is ready for imrnediate use, without waiting for the filament to warm up.

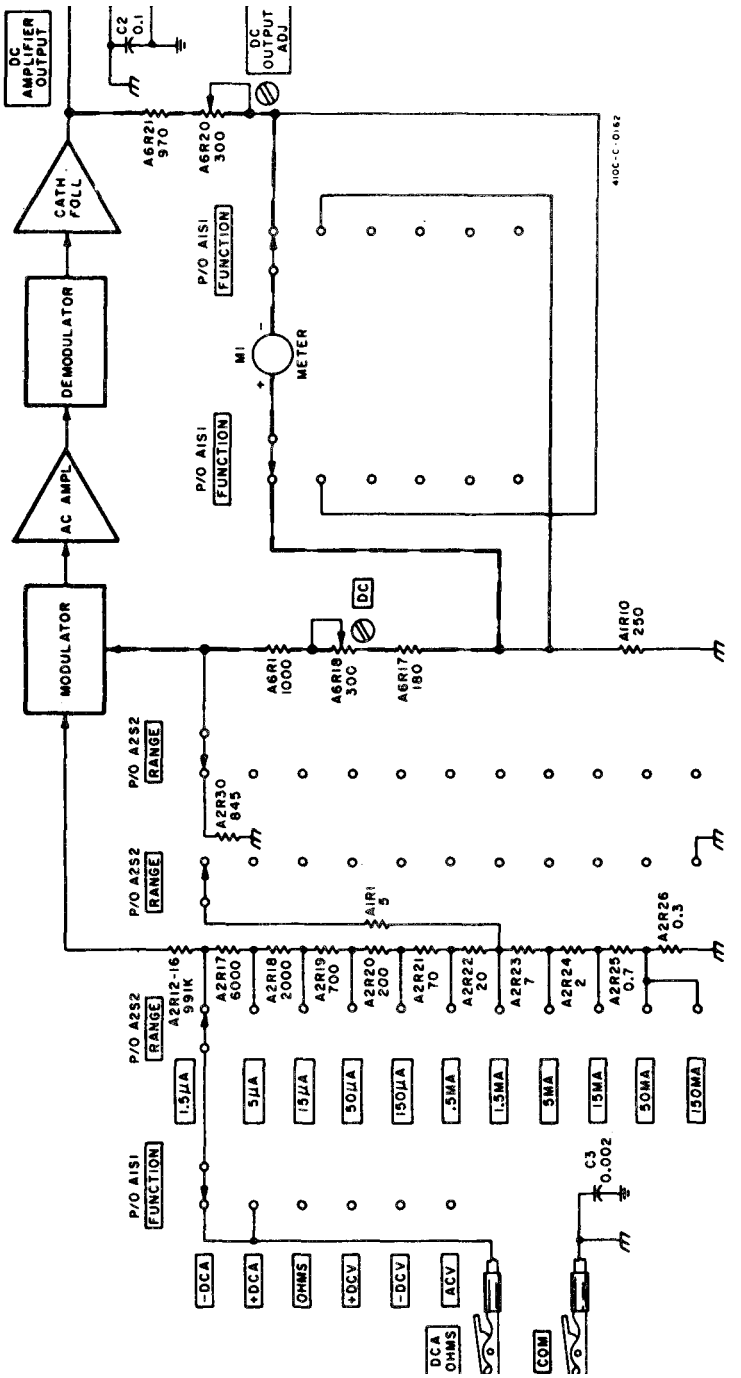


Figure 4-3. Simplified Schematic, DC Current Measurement

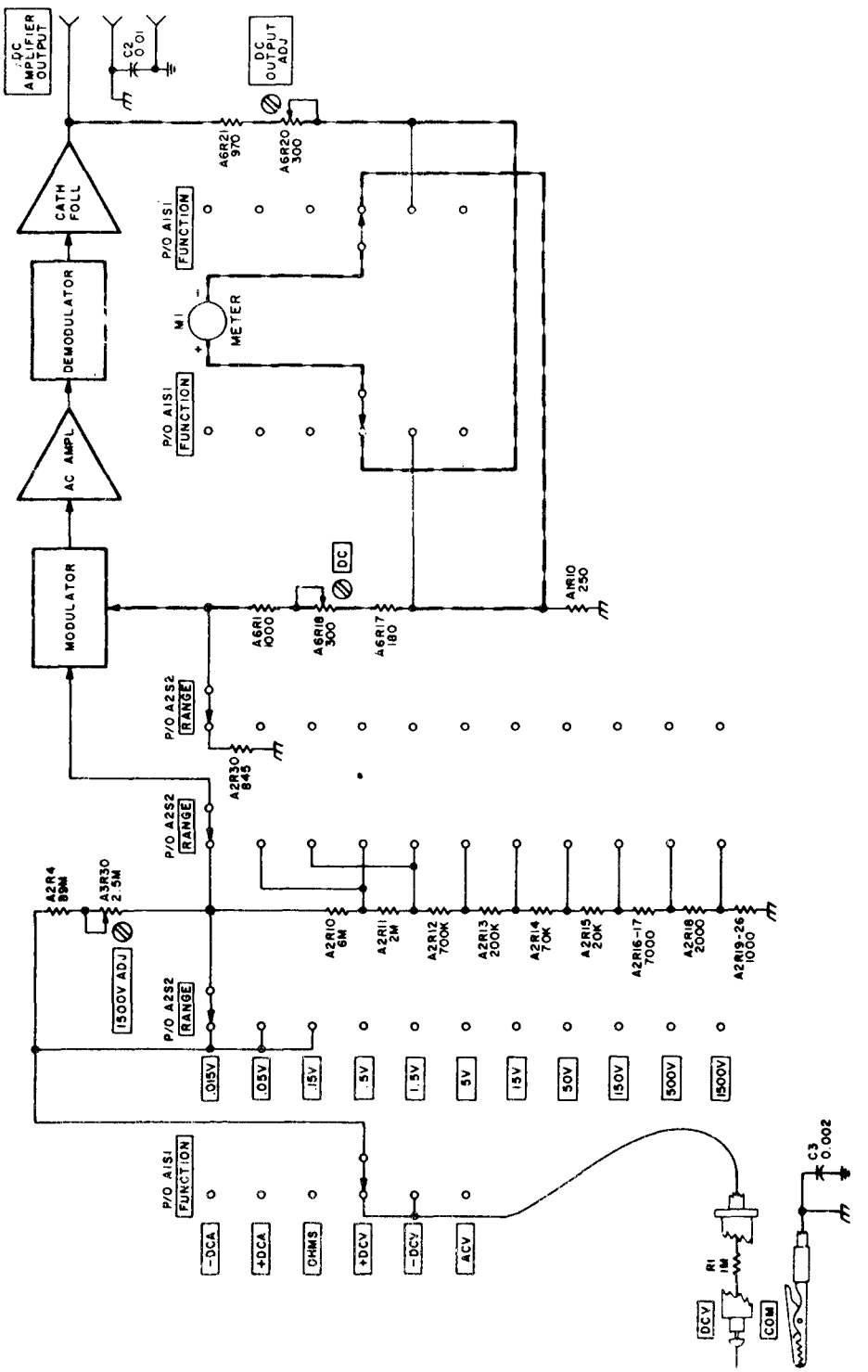


Figure 4-4. Simplified Schematic, DC Voltage Measurements

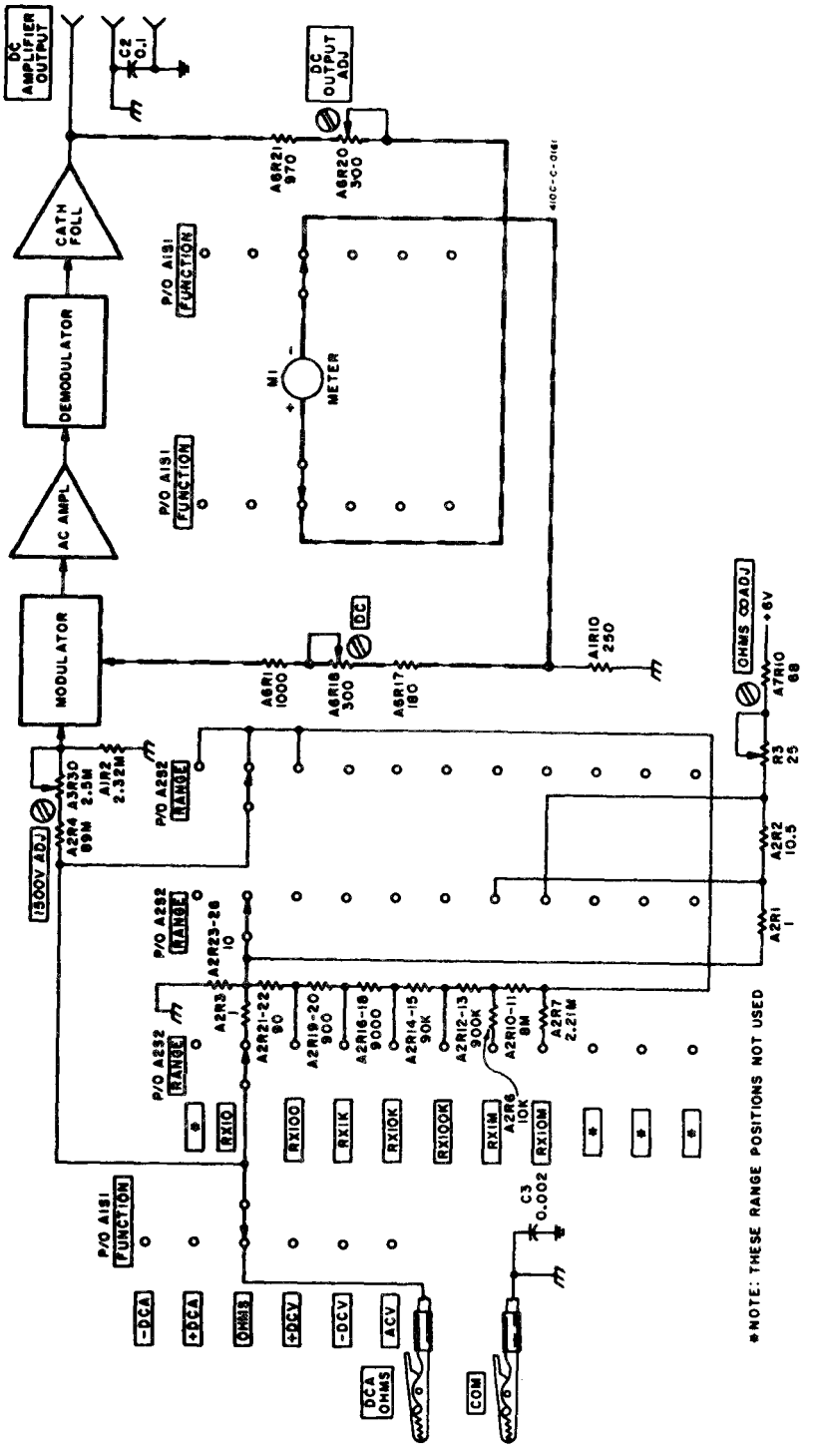


Figure 4-5. Simplified Schematic, Resistance Measurement

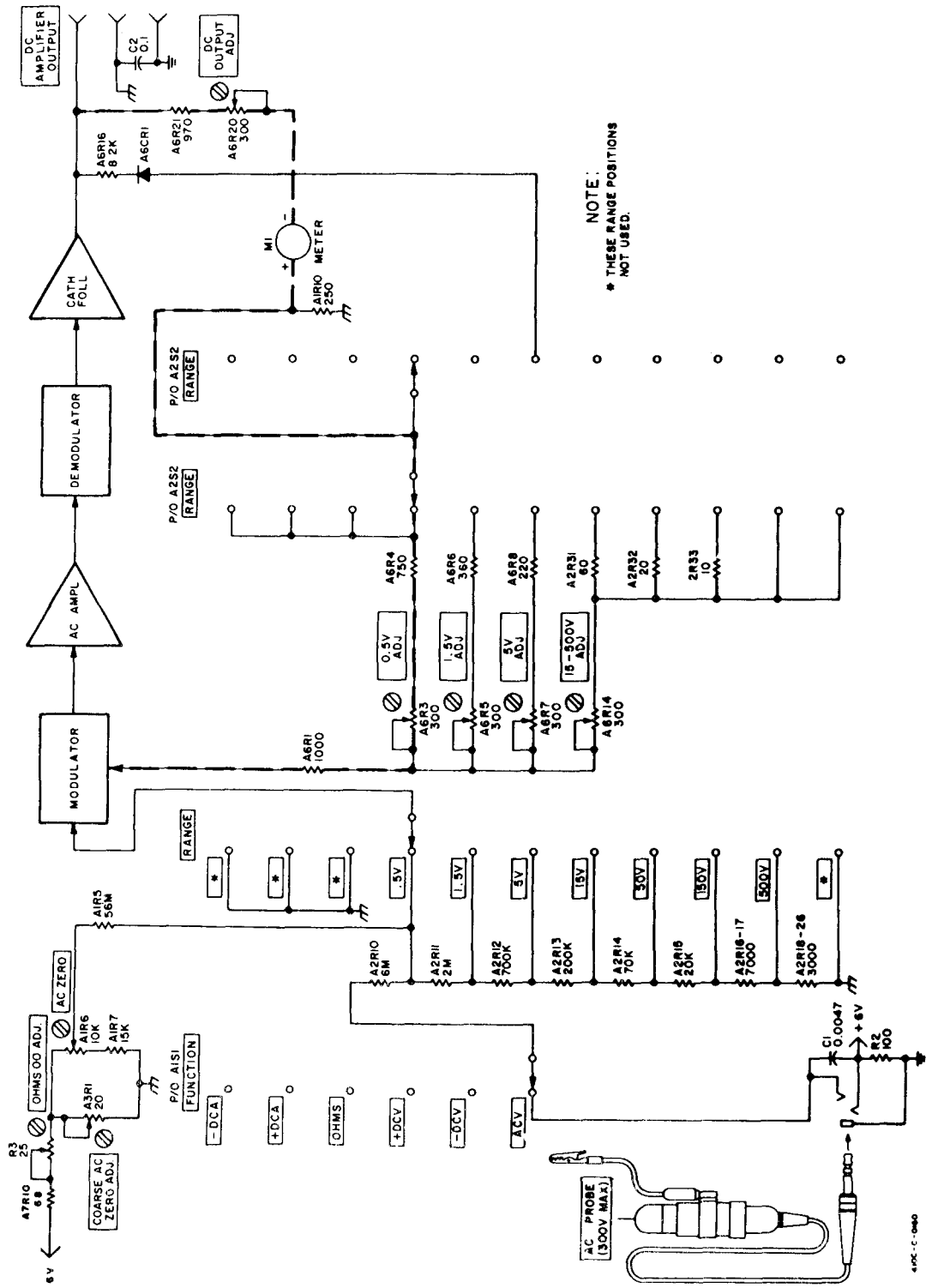


Figure 4-6. Simplified Schematic, AC Voltage Measurement

01556-2

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Use	Recommended Model
Voltmeter Calibrator	Range: .015 to 300 v Frequency: DC and 400 cps Accuracy: ±0.3% AC ±0.2% DC	AC and DC Accuracy Checks and Calibration Adjustments	Model 738BR Voltmeter Calibrator
DC Power Supply	Range: 0 to 10 v continuous	DC Ammeter Accuracy Checks	Model 723A DC Power Supply
DC Voltmeter	Range: 10 v Accuracy: ±0.2%	Accuracy Checks; Power Supply Measurements; Troubleshooting	Model 3440A/3442A Digital Voltmeter
Frequency Response Test Set	Frequency: 20 cps to 10 Mc with external oscillator Output: 2 v into 50 ohms	Frequency Response Test	Model 739AR Frequency Response Test Set
Oscillator	Frequency: 20 cps to 10 Mc Output : 2.0 v	Frequency Response Test	Model 651A Test Oscillator
RF Signal Generator	Frequency: 10 Mc to 480 Mc Output: 1.0 v	Frequency Response Test	Model 608C RF Signal Generator
Power Meter	Frequency: 10 Mc to 700 Mc Range: 1.0 v	Frequency Response Test	Model 431B Power Meter
VHF Signal Generator	Frequency: 480 Mc to 700 Mc	Frequency Response Test	Model 612A VHF Signal Generator
AC Voltmeter	Range: 115 V	Power Supply Measurements (ripple)	Model 3400A RMS Voltmeter
Electronic Counter	Frequency Range: to at least 102 cps	Chopper Frequency Adjust	Model 521C Electronic Counter
DC Standard	Output: 1000 v Accuracy: ±0.2%	DC Adjust	Model 740A DC Standard
Ohmmeter	Range: 100 MΩ Accuracy: ±5%	Troubleshooting	Model 412A DC VTVM
Thermistor Mount	Frequency: 10 Mc to 700 Mc Impedance: 50 ohm match	Frequency Response Test	Model 478A Coaxial Thermistor Mount
Probe-T-Connector	For use with 50 ohm transmission line	Frequency Response Test	Model 11042A Probe-T-Connector
10 KC Filter	High pass filter capable of 10 kc rejection	Frequency Response Test	Model K02-411A 10 KC Filter
Connector Adapter	Male BNC to male BNC	Frequency Response Test	Part No. 1250-0216
Connector Adapter	Type N male to BNC female	Frequency Response Test	Part No. 1250-0067
Resistors:			
10 MΩ	Accuracy: ±1%	Performance Checks	Part No. 0730-0168
5 MΩ	Accuracy: ±1%	Performance Checks	Part No. 0730-0125
4.5 MΩ	Accuracy: ±1%	Performance Checks	Part No. 0730-0157
500 K	Accuracy: ±1%	Performance Checks	Part No. 0721-0011
56 K	Accuracy: ±1%	Performance Checks	Part No. 0730-0053
10 K	Accuracy: ±1%	Performance Checks	Part No. 0727-0157
9 K	Accuracy: ±1%	Performance Checks	Part No. 0730-0026
1.5 K	Accuracy: ±1%	Performance Checks	Part No. 0730-0017
56 ohms	Accuracy: ±1%	Performance Checks	Part No. 0811-0341
10 ohms	Accuracy: ±1%	Performance Checks	Part No. 0727-0335

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance procedures for the Model 410C Electronic Voltmeter.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to maintain and adjust the Model 410C is listed in Table 5-1. Equipment having similar characteristics may be substituted for items listed.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks presented in this section are front panel operations designed to compare the Model 410C with it's published specifications. These operations may be incorporated in periodic maintenance, post repair and incoming quality control checks. These operations should be conducted before any attempt is made at instrument calibration or adjustment. During performance checks, periodically vary the line voltage to the Model 410C, ± 10% on either 115v or 230 v operation. A 1/2 hour warm-up period should be allowed before these tests are conducted.

5-7. ALTERNATE VOLTAGE SOURCE.

5-6. Should it be necessary to use the Model 738AR Voltmeter Calibrator to conduct these Performance Checks, the arrangement described in Figure 5-1 will provide the necessary voltage values required. However; the Model 738BR Voltmeter Calibrator is the preferred instrument for these operations.

5-9. Mechanical METER ZERO.

a. Turn instrument on. Allow at least a 20 minute warm-up period.

b. Turn voltmeter off, and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw on front panel clockwise until pointer reaches zero, moving up scale.

d. If for some reason the pointer should overshoot zero, repeat step c until desired results are obtained.

e. When pointer has been positioned at zero, rotate zero-adjust screw slightly counterclockwise to free it. If meter pointer moves to the left during this action, repeat steps c and e.

5-10. DC VOLTMETER OPERATION.

5-11. ACCURACY CHECK (DCV).

a. Set the Model 410C FUNCTION SELECTOR to the +DCV position; RANGE switch to. 015 V . Connect Model 410C DCV and COM cables to the Voltmeter Calibrator (Model 738BR) output terminals.

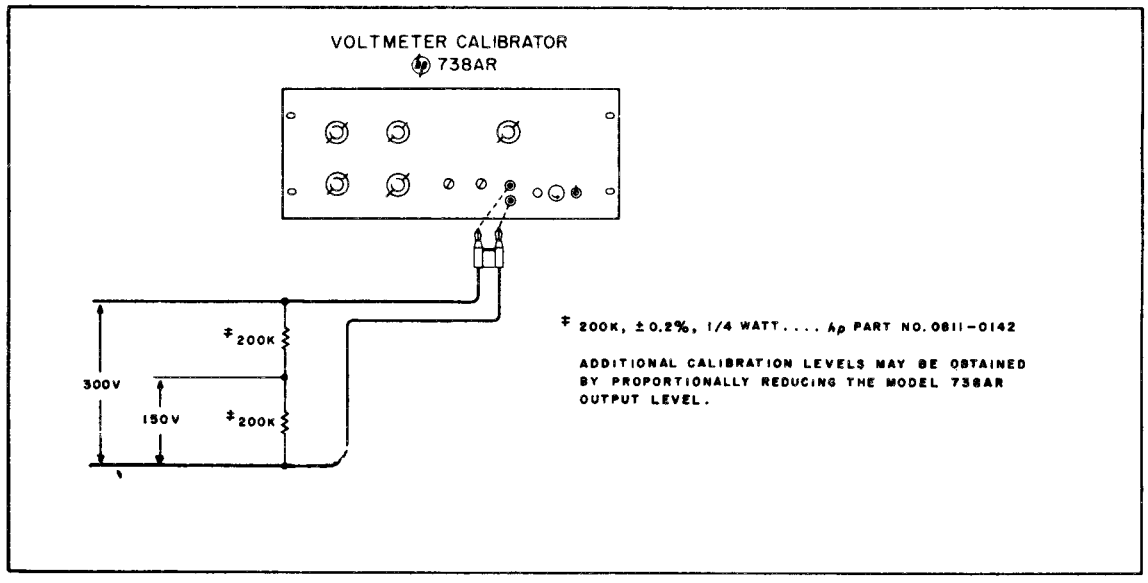

VOLTMETER CALIBRATOR
738AR
‡ 200K
300V
150V
‡ 200K
‡ 200K, ±0.2%, 1/4 WATT.... HP PART NO. 0811-0142
ADDITIONAL CALIBRATION LEVELS MAY BE OBTAINED BY PROPORTIONALLY REDUCING THE MODEL 738AR OUTPUT LEVEL.

Figure 5-1. Alternate Voltage Source

Table 5-2. DCV Accuracy Test

Model 410C Range Settings	Voltmeter Calibrator Model 738B Settings		Model 410C Meter Readings
	Range	Voltage	
.015V	1. 5-5	.015	.01.47 to .0153 V
.05V	1. 5-5	.05	.049 to .051 V
.15V	1. 5-5	.15	.147 to .153 V
.5V	1. 5-5	.5	.49 to .51 V
1.5V	1. 5-5	1.5	1.47 to l.53 V
5V	1. 5-5	5	4.9 to 5.l V
15 V	1. 5-5	15	14.7 to 15.3 V
50 V	1. 5-5	50	49 to 51 V
150V	1.5-5	150	147 to 153 V
500 V	1-3	300	290 to 310 V
1500	1-3	300	270 to 330 V

b. Adjust Voltmeter Calibrator to provide a +.015 v dc voltage.

c. Model 410C should read between 0. 0147 and 0.0153 v.

d. Readjust Model 410C and Voltmeter Calibrator (,) settings listed in Table 5-2. Note Model 410C meter readings. If Model 410C fails to meet pecifications, refer to Paragraph, 5-30 and 5–32 for proper adjustment procedure.

5-12 INPUT RESISTANCE CHECK (DCV).

a. Connect an external resistor, Rx, of lO M ohms ±1% (hp Part No. 0370-0168) in series between the voltmeter calibrator and the DCV cable of the Model 410C.

b. Set Model 410C FUNCTION selector to +DCV; RANGE to .015 V.

c. Adjust voltmeter calibrator for +.015v DC output.

d. Model 410C should read .0075 v, verifying R_{in} of 10 M ohms.

e. Table 5-3 provides settings required to verify Model 410C R_{in} on RANGES specified.

Where

$$E_{410C} = \frac{E_{738BR}}{2} \quad \text{when} \quad R_x = R_{410C}$$

$$E_{410C} = \frac{(E_{738BR})(10)}{110} \quad \text{when} \quad R_x = \frac{R_{410C}}{10}$$

5-13. DC AMMETER OPERATION.

5-14. ACCURACY CHECK (DCA).

a. Figure 5-2 describes the test arrangement required for this operation. The following additional equipment will also be required:

DC Power Supply (hp Model 723A)

DC Voltmeter (hp Model 3440A/3442A)

10 K, 1%, 1 w resistor (hp Part No. 0727-0157)

56 K, 1%, 1 w resistor (hp Part No. 0730-0053)

10 Ω, 1%, 1 w resistor (hp Part No. 0727-0335)

56 Ω, , 1%, 1/2 w resistor (hp Part No. 0811-0341)

b. Connect the Model 410C as shown in Figure 5-2; FUNCTION SELECTOR to +DCA; RANGE to 150 MA.

c. Use 56 ohm resistor for R1 and 10 ohm resistor for R2.

d. Adjust dc power supply to obtain 1.4v reading on system voltmeter.

e. Model 410C should read between 135.5 and 144.5 ma.

f. Adjust dc power supply for System voltmeter readings listed in Table 5-4. Note Model 410C meter readings.

5-15. INPUT RESISTANCE CHECK (DCA).

a. Figure 5-2 describes the test arrangement required for this operation. Replace R1 and R2 with a 10 ohm ±1% resistor (hp Part No. 0727-0335).

b. Set Model 410C FUNCTION SELECTOR to +DCA: RANGE to 150 MA.

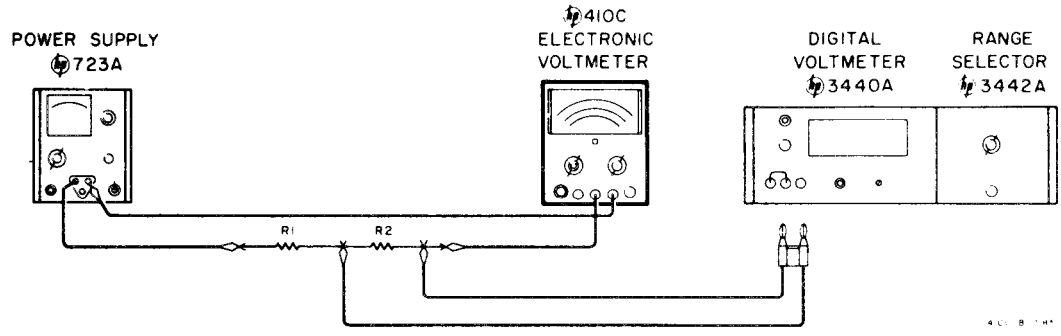


Figure 5-2. DC Ammeter Operation

Table 5-3. DCV Input Resistance Test

$R_x\Omega$, ±1%	Model 410C Range Settings	Voltmeter Calibrator Model 738B		Model 410C Meter Readings	Model 410C R_{in}
		Range	Voltage		
10 M	.015 V	1.5-5	.015	.0075 V	10 MΩ ±3%
10 M	.05 V	1.5-5	.05	.025 V	10 MΩ ±3%
10 M	.15 V	1.5-5	.15	.075 V	10 MΩ ±3%
10 M	.5 V	1.5-5	.5	.455 V	100 MΩ ±1%
10 M	1.5 V	1.5-5	1.5	1.36 V	100 MΩ ±1%
10 M	5 V	1.5-5	5	4.55 V	100 MΩ ±1%
10 M	15 V	1.5-5	15	13.6 V	100 MΩ ±1%
10 M	50 V	1.5-5	50	45.5 V	100 MΩ ±1%
10 M	150 V	1.5-5	150	136.5 V	100 MΩ ±1%
10 M	500 V	1.5-5	300	272.7 V	100 MΩ ±1%
10 M	1500 V	1.5-5	300	272.7 V	100 MΩ ±1%

Table 5-4. DCA Accuracy Test

Model 410C Range Settings	System Voltmeter Readings Model 3400A	Model 410C Meter Readings	R_1 Ω	R_2 Ω
150 MA	1.4 V	135.5 to 144.5 MA	56	10
50 MA	.4 V	38.5 to 41.5 MA	56	10
15 MA	.14 V	13.55 to 14.55 MA	56	10
5 MA	.04 V	3.85 to 4.15 MA	56	10
1.5 MA	.014 V	1.35 to 1.45 MA	56	10
.5 MA	.004 V	0.385 to 0.415 MA	56	10
150 μa	1.38 V	133.5 to 142.5 μa	56 K	10 K
50 μa	0.46 V	44.5 to 47.5 μa	56 K	10 K
15 μa	0.138 V	13.35 to 14.25 μa	56 K	10 K
5 μa	0.046 V	4.45 to 4.75 μa	56 K	10 K
1.5 μa	0.014 V	1.36 to 1.45 μa	56 K	10 K

c. Adjust dc power supply to provide system voltmeter reading of 1.50 v.

e. Model 410C should read approximately 150 ma. This will verify a R_{in} of approximately 0.3 ohms, where

$$R_{410C} = \frac{E_{total} - R_x I_{410C}}{I_{410C}}$$

f. Set Model 410C RANGE to 1.5 µa.

g. Replace Rx with a 9 K ohm ±1% resistor (HP Part No. 0730-0026).

h. Adjust dc power supply to provide system voltmeter reading of 13.5 mv.

j. Model 410C should read approximately 1.5 µa. This will verify R_{in} of 9 K on 1.5 µa range.

5-16. OHMMETER OPERATION.

a. A 10 ohm ±l% resistor(HP Part No. 0727-0335) and a 10M resistor (HP Part No. 0730-0168) will be required for this test.

b. Set Model 410C FUNCTION SELECTOR to OHMS; RANGE to RX10.

c. Set pointer to ∞using rear panel adjustment (OHMS ADJ) if required.

d. Connect COM and DCA OHMS cables across 10 ohm resistor.

e. Meter should read 1 (±5%), indicating 10 ohms.

f. Reset Model 410C RANGE to RX10M. Replace 10 ohm resistor with 10 M ohm resistor.

g. Meter should read 1 (+5%), indicating 10 M ohms.

h. If both of these ranges function properly, it can be assumed that the remainder will also . If meter does not function properly, refer to Paragraph 5-31 for adjustment procedure.

5-17. AMPLIFIER OPERATION.

5-18 [illegible] ACCURACY (

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see paras 5-19 and 5-24

5-19. AMPLIFIER GAIN CHECK.

a. Connect Voltmeter Calibrator(HP Model 738BR) output to Model 410C DCV and COM cables.

b. Connect DC Voltmeter (HP Model 3440A/3442A) to DC AMPLIFIER OUTPUT on rear panel of Model 410C. Set DC Voltmeter RANGE to 10 v.

Table 5-5. DC Voltage Output Test

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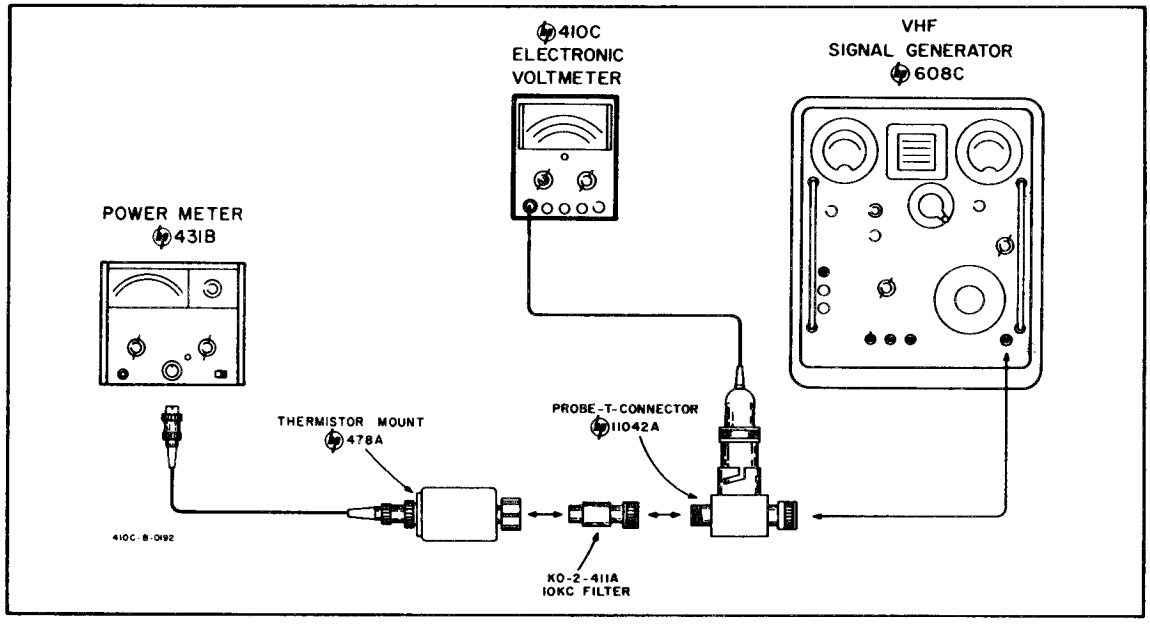


Figure 5-3. High Frequency Response Test

c. Set Model 410C FUNCTION SELECTOR to +DCV ; RANGE to .015 V.

d. Adjust voltmeter calibrator for +. 015 VDC output.

e. The dc voltmeter should read +1.5 v. This will vertfy a gain of 100, when the gain /A/ equals ^{E}DC out/^{E}410C.

5-20. AMPLIFTER NOfSE CHECK.

a. Leave the dc voltmeter connected to the DC AMPLIFIER OUTPUT as in Paragraph 5-19.

b. Set the Model 410C RANGE to 1500 V; FUNCTION SELECTOR to +DCV.

c. Short the Model 410C DCV and COM cables. Note dc voltmeter readings. This reading should be less than 7.5 millivolts .

d. Reset Model 410C RANGE to 1.5 V. DC Voltmeter should read less than 7.5 mv.

5-21. DC AMPLIFTER OUTPUT IMPEDANCE CHECK.

a. Connect an external DC Voltmeter (Model 3440A/3442A) to Model 410C DC AMPLIFIER OUTPUT terminals on rear panel.

b. Set Model 410C FUNCTION SELECTOR to OHMS position.

c. Record voltage indicated on external dc voltmeter for use as a reference.

d. Connect a 1.5 k ohm ±1% resistor(Part No. 0730-0017) across Model 410C DC AMPLI - FIER OUTPUT terminals. DC voltage recorded in step c above should not change more than 3 mv, indicating that dc amplifier output impedance is within the 3 ohm specification at dc.

5-22. AC VOLTMETER OPERATION.

5-23. 11036A AC PROBE ACCURACY CHECK.

a. Figure 5-3 describes the test arrangement required for this operation. Do not place Model 410C AC Probe in T-Connector at this point.

b. Adjust signal generator for a 0.7 volt (rms) output at 1000 cps.

c. Connect Model 11036A AC Probe to signal generator and read output on Model 410C Voltmeter (meter should read 0.7 volts).

d. Remove probe tip from Model 11036A and connect the ac probe as shown in Figure 5-4.

e. Turn signal generator to 50 Mc and adjust signal generator for a power reading of 9.8 dbm (0.7 volts) on the power meter.

f. The difference between reading on Model 410C meter and 0.7 volt reference is the ac probe error at that frequency.

g. Repeat steps f and g every 100 Mc from 50 to 700 Mc.

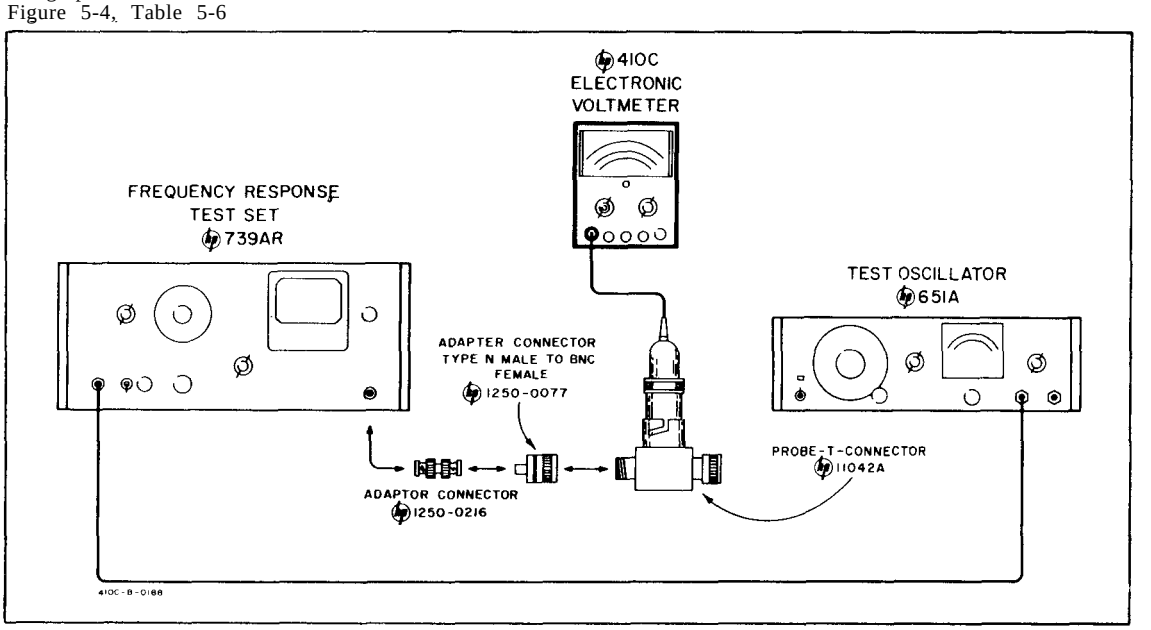


Figure 5-4. Low Frequency Response Test

AC VOLTMETER ACCURACY CHECK.

a. A Voltmeter Calibrator (Model 738BR) will be required for this operation.

b. Adjust voltmeter calibrator for 400 cps-rms output.

c. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 500 V.

d. Adjust the voltmeter calibrator to settings listed in Table 5-6. Model 410C should indicate readings within limits specified. If not, refer

5-25. AC VOLTMETER FREQUENCY RESPONSE CHECK.

a. A Frequency Response Test Set (Model 739AR), a Test Oscillator (Model 651A), an RF Signal Generator (Model 608 C), a Power Meter (Model 431 B), a Thermistor Mount (Model 478A), a Probe - T - Connector (Model 11042A), a VHF Signal Generator (Model 612A) and a 10 KC Filter (Model K02-411A) will be required for this operation. Figure 5-3 and 5-4 describe the arrangement to be

Table 5-6. AC Accuracy Test

Model 410C Range	Voltmeter Calibrator 400 cps		Model 410C Readings
	Range	Voltage Selector	
500 V	1-3	300	291 to 309 V
150 V	1.5-5	150	145.5 to 154.5 V
50 V	1.5-5	50	48.5 to 51.5 V
15 V	1.5-5	15	14.55 to 15.45 V
5 V	1.5-5	5	4.85 to 5.15 V
1.5 V	1.5-5	1.5	1.455 to 1.545 V
.5 V	1.5-5	.5	0.485 to 0.515 V

b. Connect the Model 410C as shown in Figure 5-4. Set Model 410C FUNCTION SELECTOR toACV; RANGE to 1.5 V.

c. Set frequency response test set to EXTERNAL.

d. Adjust test oscillator output AMPLITUDE to provide Model 410C reading of 1.4 V; FREQUENCY to 400 cps.

e. Set frequency response test set METER SET to convenient SET LEVEL.

f. Vary test oscillator frequency from 20 cps to 10 Mc. Model 410C should read between 1.25 and 1.55 v at all frequencies. When checking the frequency response from 20 cps to 50 cps, disconnect the 11042A from the test set up in figure 5-4. Replace the probe tip on the Model 11036A and connect directly through a 50-ohm load to the output of the Frequency Response Test Set. Connect the output of the Test Oscillator directly to the input of the Frequency Response Test Set. Observe step g throughout the entire operation.

g. If frequency response test set deflection varies from preset SET LEVEL, adjust test oscillator output amplitude to return pointer to original position.

h. To check Model 410C frequency response from 10 Mc to 480 Mc, use arrangement described in Figure 5-3.

i. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to .5 V.

j. Adjust RF signal generator to provide Model 410C reading of 0.45 V at 10 Mc. Note power meter reading; mark for future reference.

k. Vary RF signal generator frequency from 10 Mc to 480 Mc. Model 410C should read between 0.40 to 0.50 v at all frequencies.

l. If power meter pointer varies from reference determined in step j above, readjust RF signal generator OUTPUT LEVEL to return pointer to reference deflection.

m. To check Model 410C frequency response from 480 Mc to 700 Mc, replace RF signal generator with VHF Signal Generator (H-P Model 612A) and repeat steps i through m above. Model 410C should not vary more than ±10% from reference.

5-26. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-27. The following is a complete adjustment and calibration procedurE for the Model 410C. These operations should be conducted only if it has previously been established by Performance Checks, Paragraph 5-5, that the Model 410C is out of adjustment. Indiscriminate adjustment of the internal controls to "refine" settings may actually cause more difficulty. If the procedures outlined do not rectify any discrepancy that may exist, and all connections and settings have been rechecked, refer to Paragraph 5-36, Troubleshooting, for possible cause and recommended corrective action.

5-28. CHOPPER FREQUENCY ADJUST.

a. A Voltmeter Calibrator (H-P Model 738BR) and an Electronic Counter (H-P Model 52lC) and an AC Voltmeter (H-P Model 3400A) will be required.

b. Use ac voltmeter to verify Model 410C line voltage of 115 v. Chopper frequency will vary with line voltage variations.

c. Connect 410C, electronic counter, and voltmeter as ahown in Figure 5-6.1.

d. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to 1.5 V.

e. Adjust voltmeter calibrator to supply + 5 V dc to the Model 410C (DCV and COM cables).

f. Observe counter, and adjust A3R5 for a chopper frequency of 100 cps (±2 cps).

5-29. Power Supply Adjustment

a. Refer to Table 5-7 for Power Supply check points and typical voltage values. Measure dc voltages between common and designated location on Al.

b. Set Model 410C FUNCTION to ACV. Short ACV and COM cable.

Table 5-7, Power Supply Test

voltage	Location on A7	Tolerance
+ 175 v	Wht/blk and Orange	±30V
+38V	Junction of CR6 and R4	±8.0 V
+6 V	Cathode of CR8	±0.6 V
–9.1 V	Anode of CR7	+1.8V

c. Measure + 175 volt ac ripple with ac voltmeter (H-P Model 3400A). RMS value of ripple should not exceed 2.5 mv.

5-30. DC Zero Adjustment and Bias

a. Set Model 410C Function Selector to + DCV and Range Switch to .5 V.

b. Short DCV Cable to COM Cable.

c. Adjust A3R21 fully counterclockwise, and then rotate about 20° clockwise.

d. Adjust ZERO ADJ pot on rear panel for zero meter deflection. Switch to – DCV. If any deflection is observed, adjust ZERO ADJ pot to return meter pointer halfway back to zero. Check zero setting on all ranges for both + DCV and – DCV. Zero offset should not exceed 1070 in any case.

5-31. DC Amplifier Output Adjust

a. Set the Model 410C FUNCTION SELECTOR to ACV; RANGE to 5 V.

b. Connect a DC Voltmeter (H-P Model 3440A/3442A) to the dc amplifier OUTPUT on the Model 410C rear panel. Set dc voltmeter RANGE to 10 v.

c. Connect Model 410C AC Probe to voltmeter calibrator output. Adjust voltmeter calibrator to provide a 5 v, 400 cps signal.

d. Model 410C should read full scale (5 v). The dc voltmeter should indicate 1.5 V. If it does not, adjust A6R20 for 1.5 v reading.

5-32. Full Scale DC Adjustment

a. Set Model 410C. FUNCTION SELECTOR to + DCV; RANGE to .015 V.

b. Adjust DC Standard (H-P Model 740A) to apply .015 to Model 410C .

c. Model 410C should read full scale. If not, adjust A6R18 for proper pointer deflection.

d. Reset Model 410C RANGE to 1500 v. Adjust dc standard for 1000 v output.

e. Adjust A3R30 for Model 410C reading of 985 v (1% low).

f. If an error greater than ±2% of full scale exists on any range between 0.5 v and 1500 v Inclusive, select new setting for A3R30 to yield best results over these ranges. If error greater than ±2% of full scale still exists on any of the above ranges, readjust A6R18 to reduce error.

g. If error greater than ±2% of full scale exists on any range between 15 mv and 150 mv inclusive, select new setting for A6R18 to yield best results on these ranges. If error greater than ±2% of full scale still exists on any of the above ranges, readjust A3R30 to reduce error.

h. If error greater than ±2% of full scale exists on both 15 mv to 150 mv and 0.5 v to 1500 v ranges, start by readjusting A6R18 to correct 15 mv and 150 mv range. Once they are within specification, proceed to readjust A3R30 to correct 0.5 v to 1500 v range error.

5-33. OHMS ADJUST (R3).

a. Set Model 410C FUNCTION SELECTOR to ORMS; RANGE to RX10M.

b. Short OHMS and COM cables. Model 410C should read zero.

c. Vary Model 410C RANGE switch through remainder of OHMS settings. Meter should read zero, except at RX10 when meter should read about 0.1 ohm (resistance of leads).

d. Disconnect OHMS and COM cables. Model 410C meter should read ∞. If not, set OHMS ADJ (rear panel) for ∞ reading. Checks ∞ reading on all OHMS RANGE settings.

5-34. AC ZERO ADJUST.

a. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to .5 V.

b. Set AC ZERO vernier on front panel to center of rotation.

c. Short Model 410C ac Probe and ac probe common (short lead).

d. Adjust R1 for Model 410C zero deflection.

5-35. AC FULL SCALE ADJUST (.5 V RANGE).

a. Connect Model 410C ac probe to voltmeter calibrator output terminals. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 500 v.

b. Adjust voltmeter calibrator to provide 300 v, 400 cps - rms output . Model 410C should read 300 v (±3%). If not, adjust A6R14 for proper reading.

c. Continue test for remainder of Model 410C ac ranges using settings provided in Table 5-8.

5-36. TROUBLESHOOTING PROCEDURE.

5-37. This section contains procedures designed to assist in the isolation of malfunctions. These procedures are based on a systematic analysis of the

Table 5-8. AC Full Scale Adjust

Model 410C Range	Voltmeter Calibrator Model 738B Range	Voltmeter Calibrator Model 738B Voltage	Model 410C Reading ±3%	Adjustment
.5 V	1.5-5	.50	.50	A6R3
1.5 V	1.5-5	1.5	1.5	A6R5
5 V	1.5-5	5	5	A6R7
*15 V	1.5-5	15	15	A6R14
*50 V	1.5-5	50	50	A6R14
*150 V	1.5-5	150	150	A6R14
*500 V	1-3	300	300	A6R14

*A6R14 is proper adjustment of Model 410C for RANGE settings from 15 vac to 500 vac. Select proper A6R14 setting which will provide best overall results for these ranges.

instrument circuitry in an effort to localize the problem. These operations should be undertaken only after it has been established that the difficulty can not be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-26. An investigation should also be made to insure that the trouble is not a result of conditions external to the Model 410C.

5-38. Conduct a visual check of the Model 410C for possible burned or loose components, loose connections, or any other obvious conditions which might suggest a source of trouble.

5-39. Table 5-9 contains a summary of the front-panel symptoms that may be encountered. It should beueed in initial efforts to select a starting point for troubleshooting operations.

5-40. Table 5-10, in conjunction with Figure 5-5, contains procedures which may be used as a guide in isolating malfunctions. The steps in Table 5-10 describe the normal conditions which should be encountered during the checks (circled numbers Ⓝ) in Figure 5-5.

5-41. The checks outlined in Table 5-10 are not designed to measure all circuit parameters, rather only to localize the malfunction. .Therefore, it is quite possible that additional measurements will be required to completely isolate the problem. Amplifier gain may also vary slightly between instruments; therefore it should not be necessary to precisely duplicate waveforms or values described.

5-42. Voltage values indicated in Table 5-10 are based on .5 vdc input, with Model 410C RANGE switch set to .015 v.

5-43. When required, check power supply voltages as outlined in Paragraph 5-29.

5-44. Refer to Figure 5-9 for typical waveforms encountered in the Model 410C. Waveforms represent signals which occur when instrument is operating during overdriven conditions (.5 vdc input to .015 v RANGE).

5-45. SERVICING ETCHED CIRCUIT BOARDS.

5-46. The Model 410C has three etched circuit

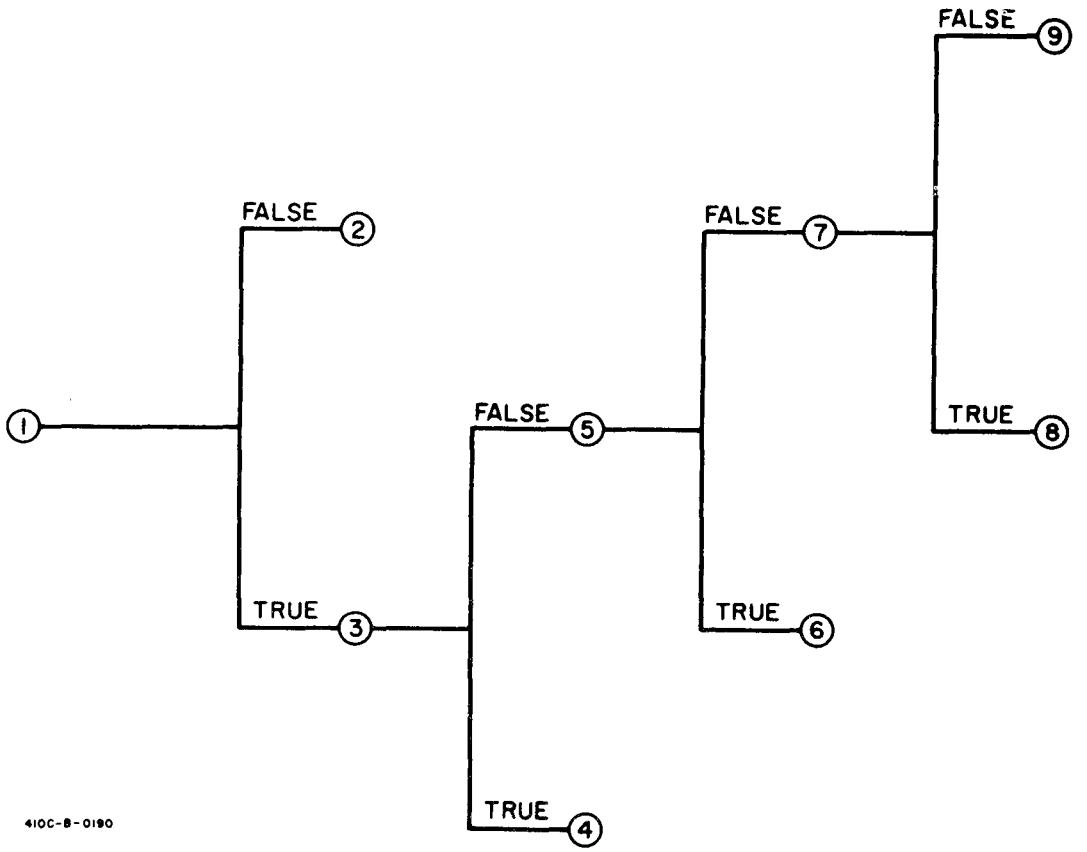


Figure 5-5. Troubleshooting Tree

boards. Use caution when removing them to avoid damaging mounted components. The ❁ Part Number for the assembly is silk screened on the interior of the circuit board to identify it. Refer to Section VI for parts replacement and ❁ Part Number information

5-47. The etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

a. Use a low-heat (25 to 50 watts) small-tip soldering iron, and a small diameter rosin core aoider.

b. Circuit components can be removed by placing the soldering iron on the component lead on either aide of the board, and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate, or cause damage to the component.

c. Component lead hole should be cleaned before inserting new lead.

d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

e. Clean excess flux from the connection and adjoining area.

f. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

5-48. CHOPPER ASSEMBLY INSTALLATION.

a. Figure 5-6 describes the physical orientation of chopper assembly on printed circuit board. Note location of chopper assembly serial number in relation to circuit board pins.

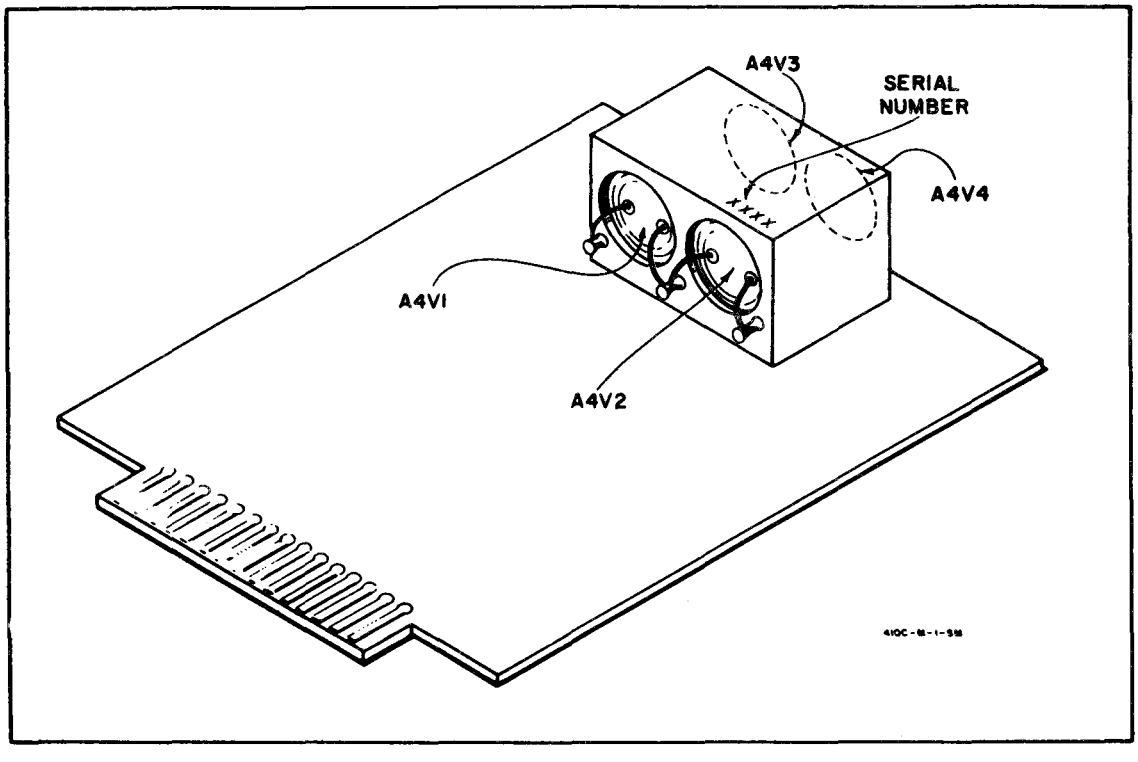


Figure 5-6. A4 Chopper Assembly Installation

Table 5-9. Front Panel Troubleshooting Procedure

FRONT PANEL SYMPTOM	POSSIBLE CAUSE
No meter deflection with input. ON - OFF lamp not glowing.	Check fuse (F1)
In -DCV, pointer deflects 1/2 scale. In +DCV pointer pegs down scale.	Check A3C5
In +DCV pointer pegs down scale. In -DCV pointer pegs up scale.	Check A3Q1, A3C6 or A3C12
Excessive jitter. 0.5 v range or above can not be properly adjusted.	Check A2R2
DC offset in excess of 1%.	Check chopper assembly and A3V1
*DCA mode out on 50 ma and 150 ma ranges.	Check A2R25 and A2R26
*If ∞ ADJ is effective in ranges from RX10 to RV1M, then shifts when RANGE switch is set to RX10M.	Check A2R2
*AC ZERO will not adjust properly. Pointer responds to input variations.	Check A1R5, A1R6, A1R7 and A3R31
*Operates in DCV mode on ranges .015 v to .15 v, but fails on higher ranges.	Check A2R2 and A3R30
DC amplifier output is +1.5 v. Meter will not deflect full scale in DCV or DCA mode.	Check A6R21, A6R20, A6R1, A6R18 and A6R17.
*Meter pegs up scale on all ranges. +DC Amplifier output is high regardless of mode of operation.	Check A1R10
In ACV mode pointer will not deflect full scale with proper input applied.	Refer to Paragraph 5-34
Operates on all ranges in ACV mode except 5 v ac position.	Check A6R16 and A6CR1.
Instrument inoperative in all modes. Meter has slight random drift pattern.	Check chopper assembly. Connect 1 M ohm resistor across A4V1. If photocell were open, meter will now respond to input. Use 100 k resistor to check DC - Modulator.
Meter oscillates full scale at rate of 5 - 10 cps.	Check chopper assembly. Connect 1 M ohm resistor across A4V2. If photocell were open, instrument will now respond to input. Use 100 k resistor to check DC - Modulator.
No ac zero.	Check C1 for short to chassis Check ac probe
No deflection on OHMS; dc ranges operative.	Check OHMS and DCA lead for short to common at alligator clip.
.5 and 1.5 VAC range will not track.	Check peak diode. Subsitute know good ac probe.
5 VAC range will not track.	Check A6CR1

*Refer to (6) Table 5-10.

Table 5-10

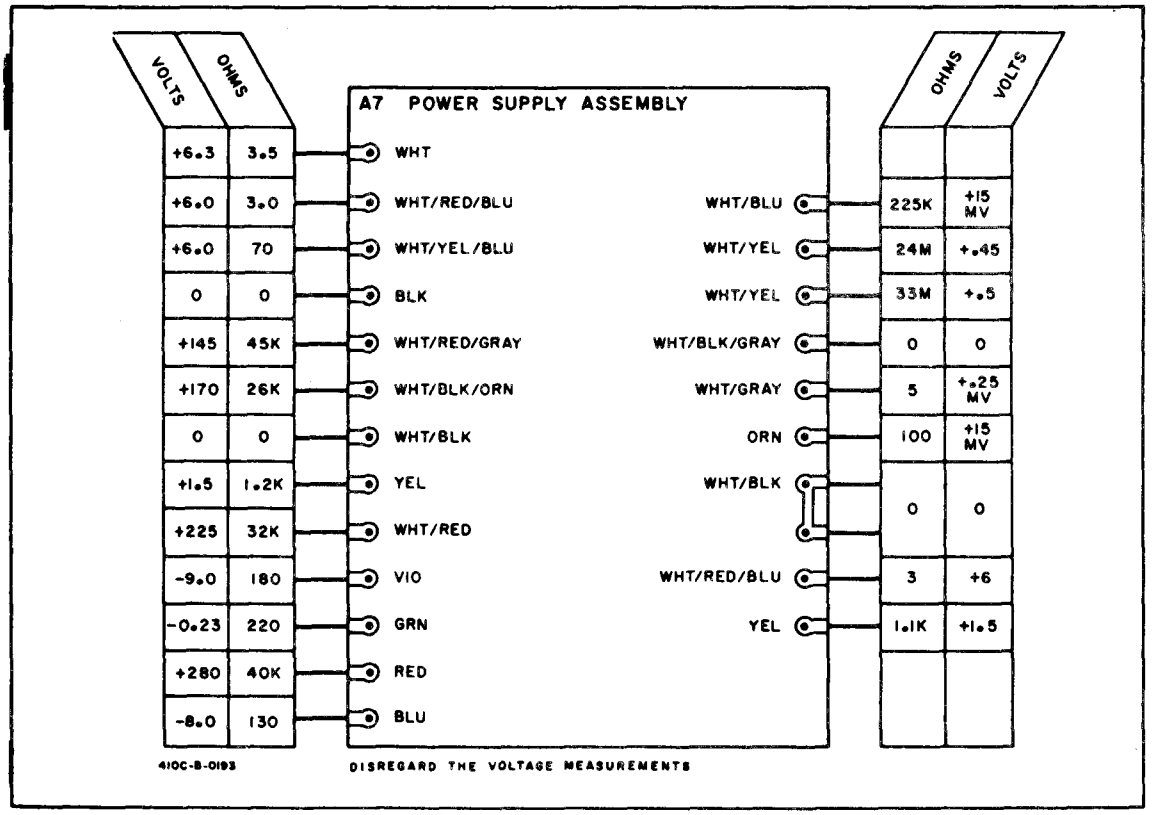


Figure 5-7. Power Supply Measurements

Table 5-10. Troubleshooting Procedure

① Check power supply voltage values using the procedure outlined in Paragraph 5-29. If voltages are correct, proceed to ③ . If voltages are incorrect, proceed to ② .	⑤ Measure the dc voltage at Pin 1, A3. This voltage is typically 13-15 mv. If this voltage is correct, proceed to ⑥ ; if not, proceed to ⑦ .
② If malfunction appears in the power supply, and adjustment of the chopper frequency to 100 cps does not reduce the error, refer to Figure 5-7 for further investigation. Check voltage and resistance values listed. When deviation is noted, trace circuit investigating for faulty component.	⑥ Investigate switch circuit. Refer to astericks in Table 5-9 for hints on how to troubleshoot switch circuit.
③ Measure the dc voltage at the DC AMPLIFIER OUTPUT on Model 410C rear panel. Under overdriven conditions specified, output should be approximately +4.0 v. If this measurement is correct, proceed to ④ ; if not, proceed to ⑤	⑦ Observe input voltage to demodulator using an oscilloscope. Refer to Figure 5-9 for normal waveform under overdriven conditions specified. If waveform is normal, proceed to ⑧ ; if not, proceed to ⑨ .
④ Trace circuit from Pin 11, A3 to Pin 2, A6. Use ohmmeter to check values of A6R21, A6R20 , A6R17 and A6R1. Refer to Figure 5-10 for pertinent component and dc voltage values.	⑧ Investigate the demodulator and cathode follower A1V3B. Refer to Figure 5-10 for typical voltage and parameter values. Refer to Table 5-9 for method to check for open demodulator .
	⑨ Investigate the modulator and amplifier to include A1V1A, Q1 and Q2. Refer to Figure 5-10 for typical voltage and parameter values . Refer to Table 5-9 for method to check for open modulator.

01566-2

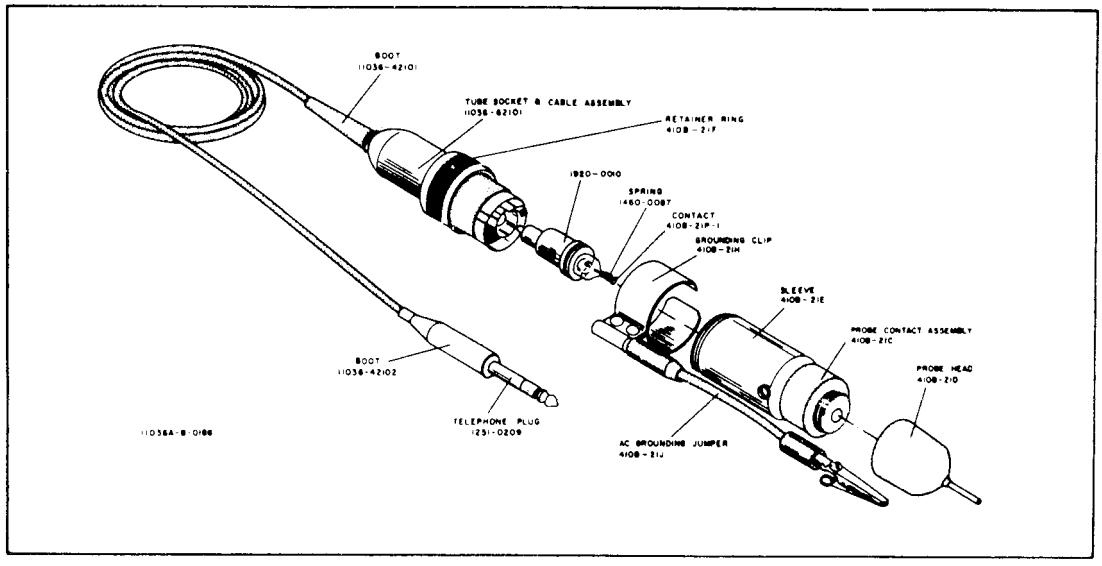


Figure 5-11. Model 11036A AC Probe (Exploded View)

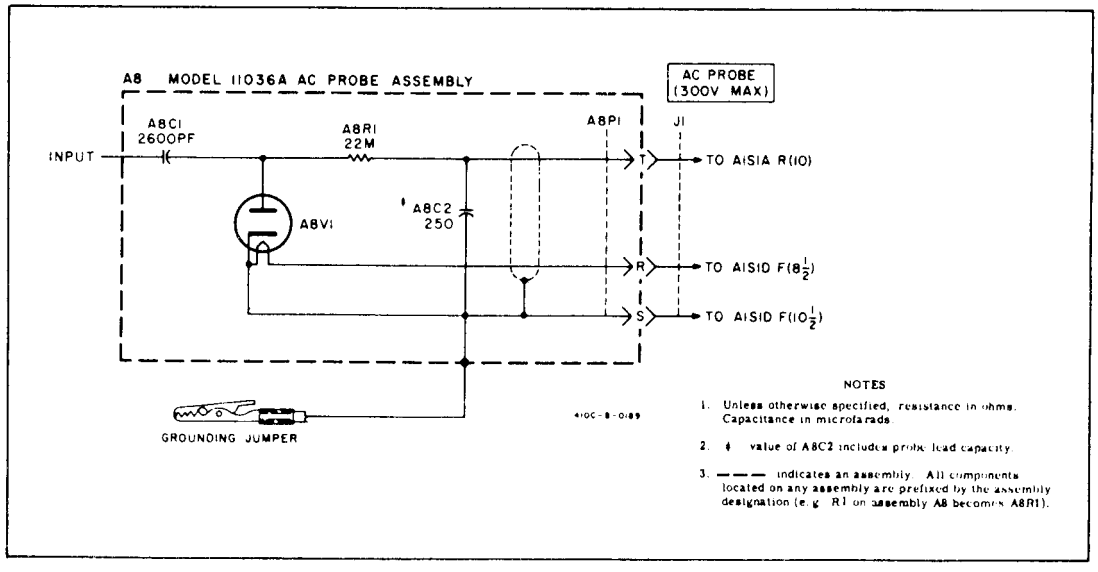


Figure 5-12. Model 11036A AC Probe Schematic

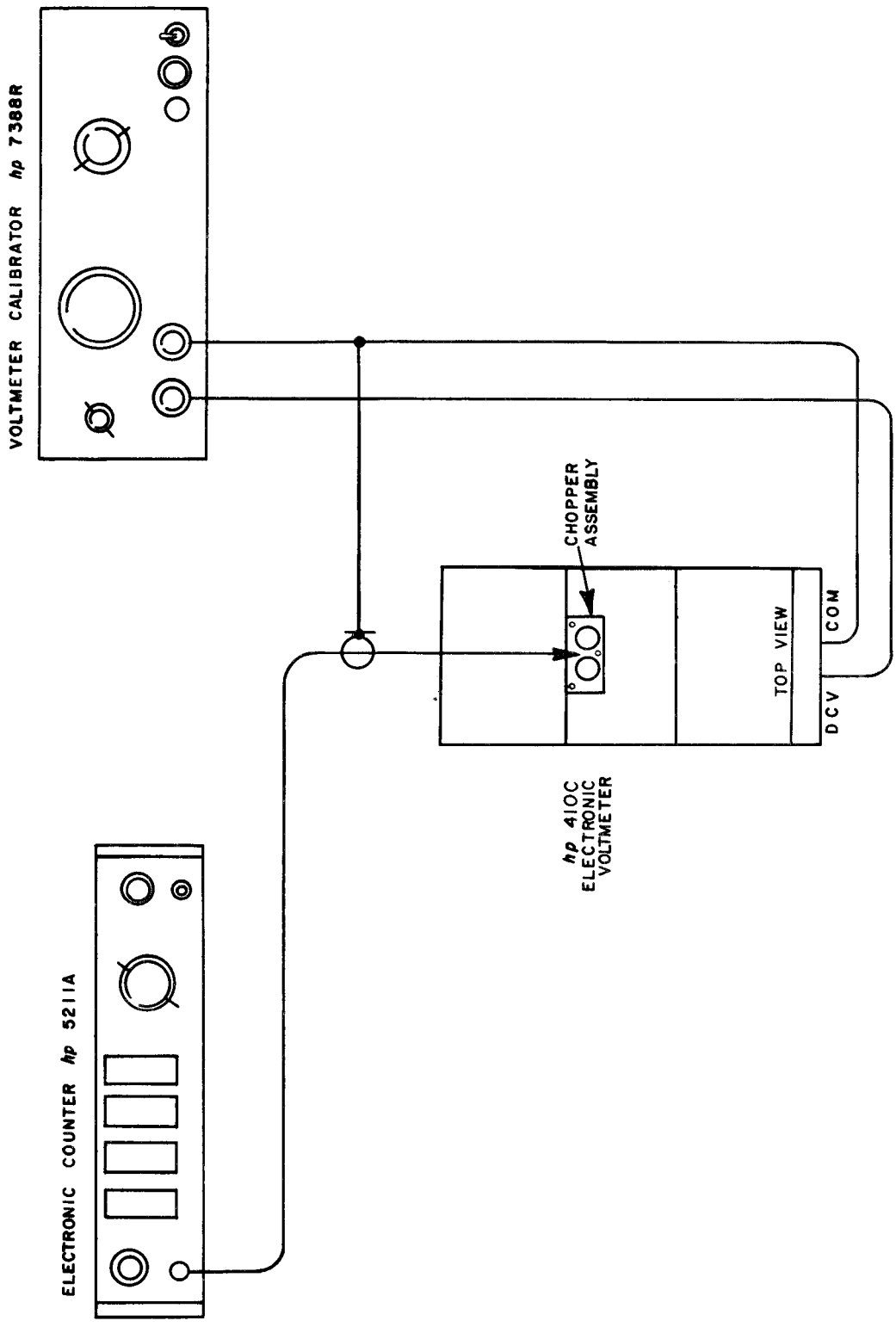


Figure 5-6.1. Chopper Frequency Adjust Setup.

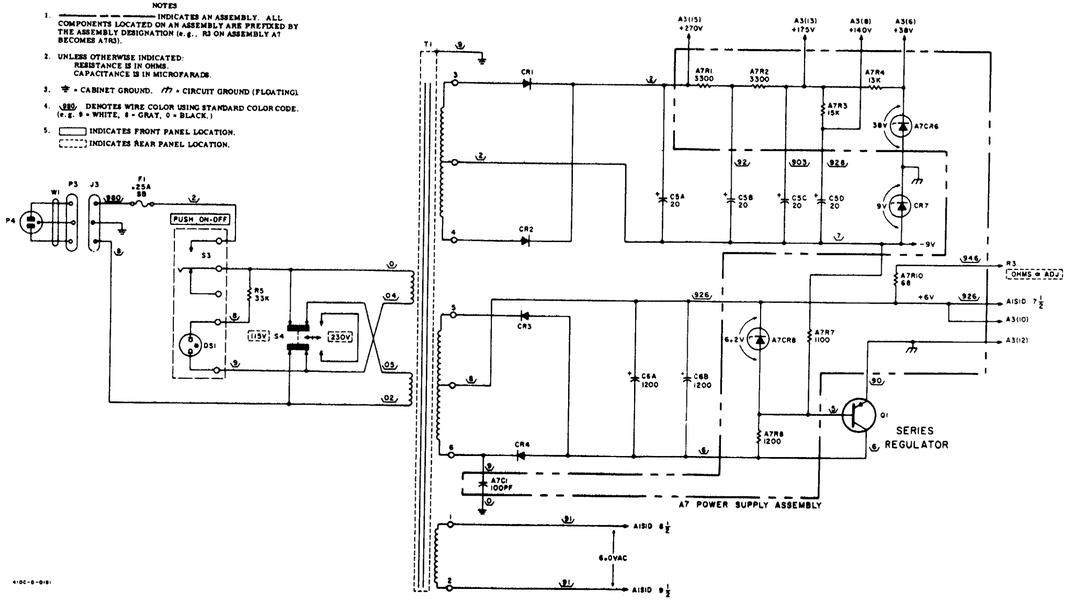


Figure 5-8.

Power Supply Schematic

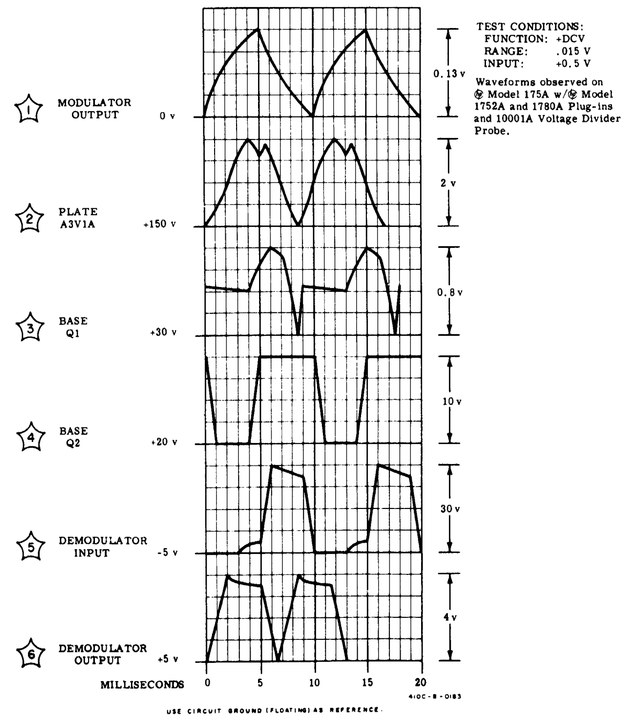
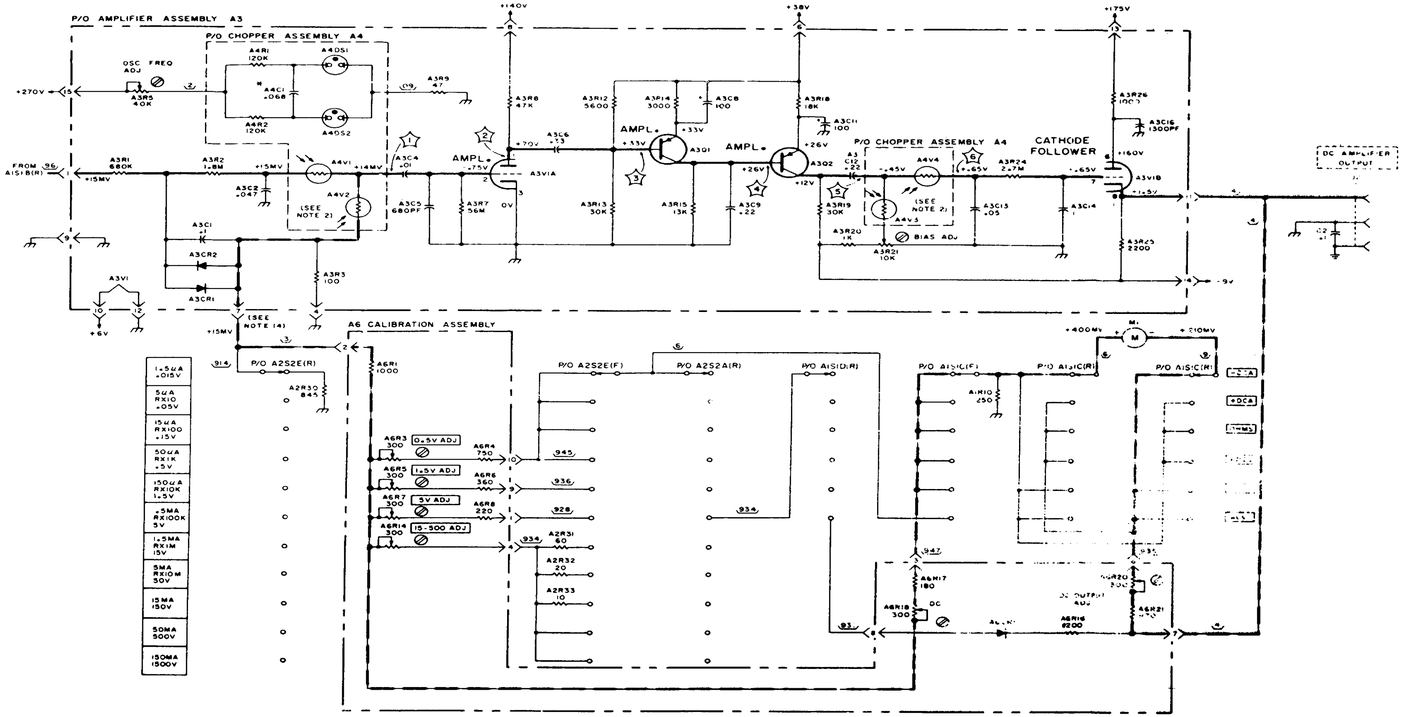


Figure 5-9. Typical Amplifier Waveforms



NOTES

1. ——— INDICATES AN ASSEMBLY. ALL COMPONENTS LOCATED ON AN ASSEMBLY ARE PREFIXED BY THE ASSEMBLY DESIGNATION (I.E., R3 ON ASSEMBLY A7 BECOMES A7R3).
2. — — — — INDICATES SUBASSEMBLY.
3. ——— INDICATES DC FEEDBACK.
4. A4V1 AND A4V3 ARE LIGHTS THAT SIMULTANEOUSLY BY A4DS1, AND A4V2 AND A4V4 ARE LIGHTED BY A4DS2.
5. UNLESS OTHERWISE NOTED: RESISTANCE IS IN OHMS CAPACITANCE IS IN MICROFARADS
6. ⏚ = CABINET GROUND. ⏚ = CIRCUIT GROUND (FLOATING)
7. ⑧ OPTIMUM VALUE SELECTED AT FACTORY. AVERAGE VALUE SHOWN.
8. P/O PART OF.
9. 333 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (E.G. 9 = WHITE, 3 = ORANGE, 5 = GREEN.
10. SWITCHES ARE SHOWN IN FULL CCW POSITIONS.
11. DC VOLTAGES SHOWN ARE TYPICAL UNDER THE FOLLOWING CONDITIONS:
    FUNCTION: -DCV
    RANGE: 5 V
    INPUT: -0.5 V
12. ◯ INDICATES PANEL ADJUST. ⊘ INDICATES SCREWDRIVER ADJUST.
13. ▭ INDICATES FRONT PANEL LOCATION. ▭ INDICATES REAR PANEL LOCATION.
14. SCHEMATIC ARRANGEMENT OF THE ADDED COMPONENTS FOR EQUIPMENTS PREFIXED 880:

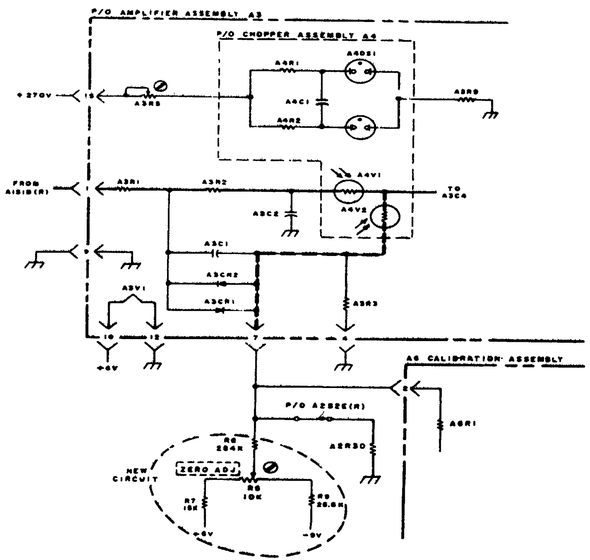


Figure 5-10. Amplifier Schematic

A1S1A
A1S1B
A1S1C
A1S1D
A2S2A
A2S2B
A2S2C
A2S2D
A2S2E
FRONT
REAR
FUNCTION
AC ZERO
ACV
-DCV
+DCV
OHMS
+DCA
-DCA
A1S1
AC ZERO
A1R5
RANGE
A2S2
A1R1 5
A1R2 2.32M
A1R10 250
A1R8 56M
A1R7 15K
A1R6 10K
A3R31 20
COARSE AC ZERO ADJ
A7(+6V)
T1(1)
T1(2)
A6R17(PIN 3)
A3R1 (PIN 1)
A6CR1 (PIN 8)
OHMS ∞ ADJ (R3)
M1(+)
A6R20 (PIN 6)
M1(-)
DCV
DCA OHMS
COM
AC PROBE (300V MAX)
C8 .002
C1 .0047
R2 100
A2R4 89M
A2R19 700
A2R20 200
A2R21 70
A2R22 20
A2R23 7
A2R24 2
A2R25 0.7
A2R26 0.3
A2R10 6M
A2R11 2M
A2R12 700K
A2R13 200K
A2R14 70K
A2R15 20K
A2R16 1K
A2R18 2K
A2R17 8K
A2R6 10K
A2R7 2.21M
A2R3
A2R30 845
A2R30 2.8M
1000V ADJ
A6R4 (PIN 10)
A6R6 (PIN 9)
A6R8 (PIN 1)
A6R14 (PIN 4)
A6R1 (PIN 2)
J2
A7

NOTES

1. SWITCHES ARE SHOWN IN FULL CCW POSITIONS.
2. P/O PART OF.
3. CAPACITANCE IN MICROFARADS AND RESISTANCE IN OHMS, UNLESS OTHERWISE SPECIFIED.
4. ⏚ EARTH GROUND; ⫽ CIRCUIT COMMON.
5. ▬▬ INDICATES CIRCUIT GROUND BUS.
6. ◯ INDICATES PANEL ADJUST; ⊘ INDICATES SCREWDRIVER ADJUST.
7. 937 INDICATES WIRE COLOR USING STANDARD COLOR CODE. (i.e., 9 = WHITE, 3 = ORANGE, 7 = VIOLET.)
8. ✱ OPTIMUM VALUE SELECTED AT FACTORY. AVERAGE VALUE SHOWN.
9. ▭ INDICATES FRONT PANEL LOCATION. ⬚ INDICATES REAR PANEL LOCATION.

Figure 5-13. RANGE and FUNCTION Switching (Pictorial)

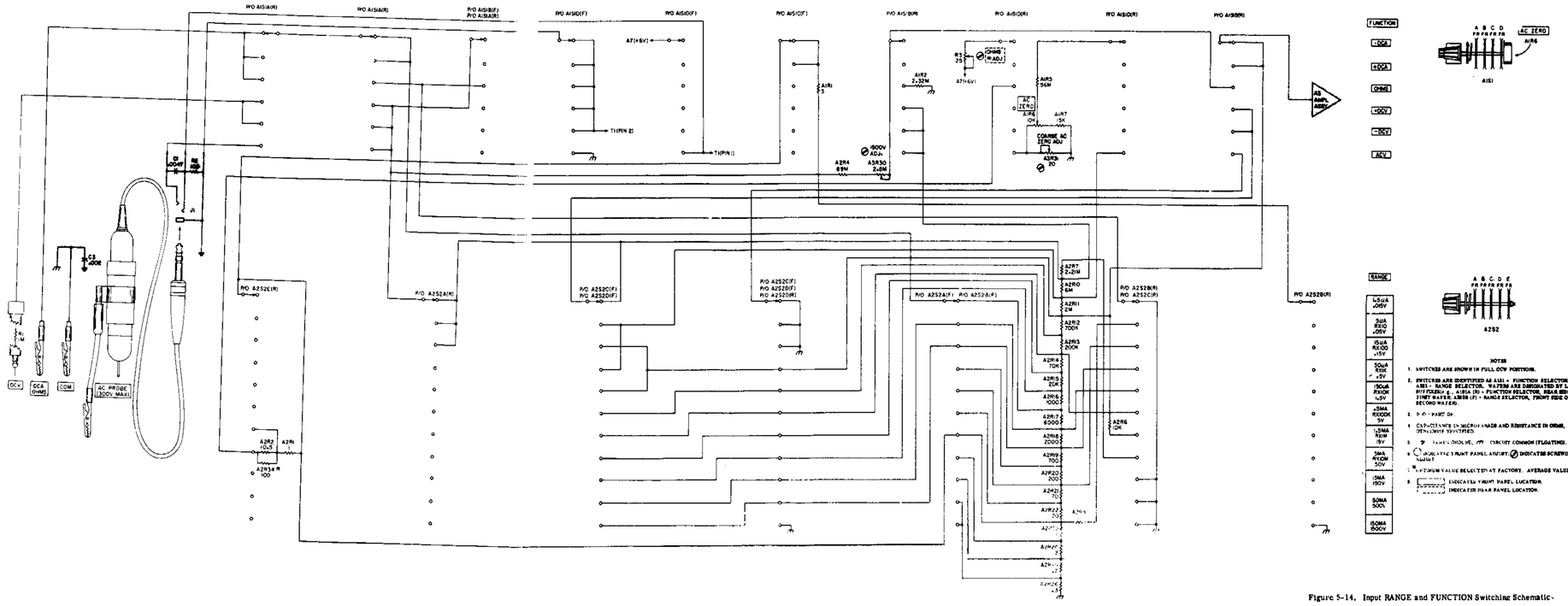


Figure 5-14. Input RANGE and FUNCTION Switching Schematic

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USACDCEC (.1)
USACDCCEA (1)
USA CDCCEA Ft Huachuca (1)
Eighth USA (5)
SAAD (5)
TOAD (5)
LEAD (3)

NG: None.

USAR: **None.**

For explanation of abbreviations used, see AR **320-50.**

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THE METRIC SYSTEM AND EQUIVALENTS

'NEAR MEASURE

. Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches
1 Kilometer = 1000 Meters = 0.621 Miles

'VEIGHTS

Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces
1 Kilogram = 1000 Grams = 2.2 lb.
1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
1 Liter = 1000 Milliliters = 33.82 Fluid Ounces

SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches
1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet
1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches
1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

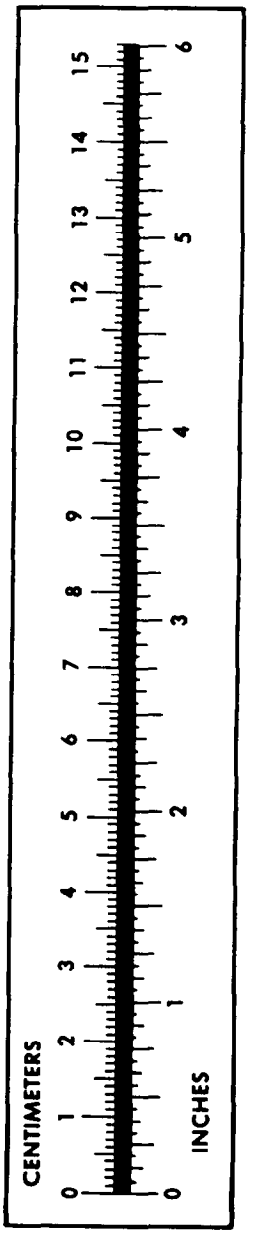
TEMPERATURE

5/9(°F - 32) = °C
212° Fahrenheit is evuivalent to 100° Celsius
90° Fahrenheit is equivalent to 32.2° Celsius
32° Fahrenheit is equivalent to 0° Celsius
9/5C° + 32 =°F

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
ıts	Liters	0.473
arts	Liters	0.946
allons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
ers	Gallons	0.264
ms	Ounces	0.035
ograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pounds-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
lometers per Liter	Miles per Gallon	2.354
meters per Hour	Miles per Hour	0.621



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